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Forest Pest Management Report

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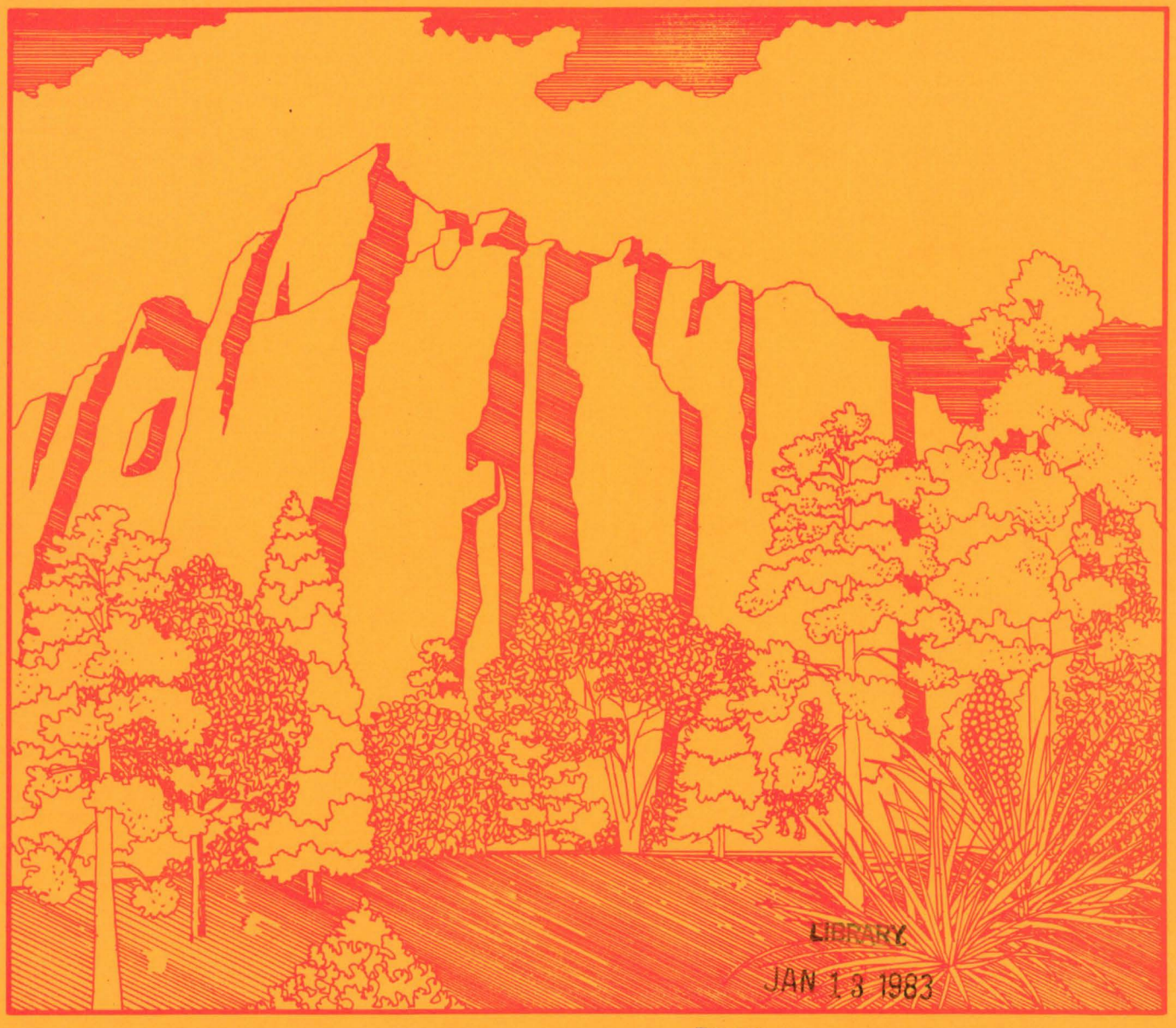
WESTERN SPRUCE BUDWORM DAMAGE
ASSESSMENT PROJECT, 1981

Carson National Forest
New Mexico

Progress Report No. 4

August 1982



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WESTERN SPRUCE BUDWORM DAMAGE ASSESSMENT PROJECT, 1981

Carson National Forest
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ABSTRACT

In the Southwest, little information has been collected on tree losses caused by the western spruce budworm. Thus, a long-range damage assessment project was initiated in 1978 on the Carson National Forest. Twelve 1-acre assessment blocks were permanently established in 1978; an additional five blocks were added in 1979. All coniferous trees greater than 5 inches d.b.h. were permanently tagged and measured. A subsample of nine 1/100-acre fixed plots per block was used to assess all trees less than 5 inches d.b.h. Defoliation, top-kill, tree mortality, and insect densities were measured annually on these plots.

Douglas-fir, true fir, and spruce were the principal host species; Douglas-fir was the most abundant species on assessment blocks. Defoliation by site class increased from an initial range of 38.8 to 64.0 percent in 1978 to 76.6 to 93.2 percent in 1981. On assessment blocks 1 through 12, confirmed top-kill of seedlings and saplings increased from none in 1978 to 12.3 and 10.3 percent, respectively, in 1980. Poles and sawtimber confirmed top-kill increased from 0.2 and 0.3 percent in 1978 to 7.3 and 4.3 percent, respectively, in 1980. Mortality in pole- and sawtimber-size trees increased from none in 1978 to 0.8 and 1.0 percent, respectively, in 1981. However, the budworm was probably not the primary cause of this mortality. Seedling and sapling mortality increased from 0.1 and 0.2 percent in 1978 to 7.0 and 2.2 percent, respectively, in 1981. In summary, there was an increasing trend for top-kill and mortality in all size-class trees on the assessment blocks.

Growth loss studies by the University of Arizona's Laboratory of Tree-Ring Research are underway. The present and past infestations are being investigated.

Larval densities on blocks 1 through 12 for the years 1979 through 1981 averaged 25.4, 16.5, and 17.3 larvae per 100 buds, respectively. Resulting defoliation was consistently in the 82- to 85-percent range. Egg mass densities on the same blocks fluctuated from a low of 20.6 per m^2 foliage in 1978 to a high of 58.6 per m^2 foliage in 1980. The egg mass density was 23.7 per m^2 foliage in 1981.

Methods, conclusions, and management implications are discussed in this report.

I. INTRODUCTION

The western spruce budworm, Choristoneura occidentalis Freeman, is a major defoliator of Douglas-fir (Pseudotsuga menziesii) and true fir (Abies spp.) in the western United States. During outbreaks of this insect, repeated defoliation of host trees causes growth loss, top-kill, and tree mortality. Faced with potentially serious tree damages, a forest manager must decide if pest management is warranted and, if it is, determine what methods are preferred. The manager must select a method that will be effective, economical, and environmentally acceptable, as well as compatible with management objectives. In order to make these decisions, the manager must have reliable damage information.

In the Southwest, little information has been collected on tree losses caused by the budworm; thus, a long-term damage assessment project was initiated in 1978. This report summarizes the methods used to assess tree damages and the results of sampling for 1978 through 1981.

II. OBJECTIVES

The purpose of this evaluation is to assess damages to Douglas-fir, true fir, and spruce caused by the western spruce budworm on the Carson National Forest, New Mexico. Specific objectives of the evaluation follow:

A. Growth Loss

1. Determine the amount of growth loss and recovery for past infestations that occurred from 1922-1966, and the current infestation which began in 1975.

2. Estimate densities of larvae and egg masses and relate these population indexes to tree defoliation and subsequent growth loss.

3. Determine if differences in growth loss and recovery occur among various site classes and timber-size classes.

4. Determine if differences in growth loss can be correlated by site classes and timber-size classes.

B. Top-kill and Tree Mortality

1. Determine the annual amount of top-kill and tree mortality caused by the current budworm infestation.

2. Estimate densities of larvae and egg masses and relate these population indexes to tree defoliation and subsequent top-kill and mortality.

3. Determine if differences in top-kill and mortality occur among various site classes and timber-size classes.

III. OUTBREAK HISTORY

The evaluation areas are located on the Taos, Questa, and Tres Piedras Ranger Districts of the Carson National Forest (fig. 1, appendix). Several infestation cycles of budworm have occurred on this Forest since records were first kept in the early 1920's. On the western part of the Carson, including the Tres Piedras District, an outbreak occurred from approximately 1922 to 1935. Then in the early 1940's, and again during the 1950's, widespread infestations occurred on the Tres Piedras, Taos, and Questa Ranger Districts. Infested areas on the Tres Piedras Ranger District were sprayed with DDT in 1955. Another budworm outbreak occurred in the 1960's and portions of the following units were treated with DDT: Taos Ranger District, 1962; Tres Piedras Ranger District, 1963; and Taos and Questa Ranger Districts, 1966. No visible defoliation was documented on the Tres Piedras Ranger District after 1963. The infestation remained in untreated portions of the Taos and Questa Ranger Districts until 1968, and then collapsed.

The current infestation was detected in 1975 when 520 acres of defoliation were observed on the Rio Pueblo de Taos watershed, Taos Pueblo Indian Reservation. The infestation increased manyfold in 1976 on the reservation and the adjoining Carson National Forest. An aerial survey of the Taos and Questa Ranger Districts in 1978 revealed over 15,000 acres of defoliation, and in 1979, over 30,500 acres. In 1980, over 62,500 acres were defoliated on the 2 Districts, plus about 550 acres on the Tres Piedras Ranger District. On these 3 Districts in 1981, defoliation occurred on more than 94,200 acres. Total acres defoliated in 1981 (including those on the El Rito Ranger District and on Indian and private land adjacent to the Carson National Forest) were approximately 135,000 acres. Egg mass data indicate that heavy defoliation will continue to occur over most of the outbreak area in 1982.

IV. METHODS

A. Block Establishment

Twelve 1-acre blocks were permanently established in June 1978: nine blocks were located in drainages of the Rio Fernando de Taos on the Taos Ranger District (Capulin Canyon, Garcia Park, La Jara Canyon, and Palo Flechado Pass) and three blocks in the Cabresto Creek drainage on the Questa Ranger District (figs. 2-6, appendix). Little or no defoliation had occurred on these blocks prior to their establishment. First aerial detection of defoliation in the vicinity of the blocks was as follows: Capulin Canyon and Garcia Park, 1976; La Jara Canyon, Palo Flechado Pass, and Cabresto Canyon (blocks 11 and 12), 1977; and Cabresto Canyon (block 9), 1978.

In 1979, five additional blocks were established to serve as check blocks: four blocks (Nos. 13-16) near Osha Mountain on the Taos Ranger District and one block (No. 17) near Burned Mountain on the Tres Piedras Ranger District (figs. 7 and 8, appendix). However, budworm populations were found on the Osha Mountain blocks in 1979 and on the Burned Mountain block in 1980. Defoliation was detected aerially on Osha Mountain in 1981.

Dwarf mistletoe is widespread in Douglas-fir stands on the Carson National Forest. But, because it causes tree damages similar to those resulting from budworm defoliation, mistletoe's presence on study blocks would make it difficult to analyze damages due to budworm. For this reason, most of the damage assessment blocks were established in stands with little or no mistletoe. However, half of block 7 and most of block 14 are heavily infected with dwarf mistletoe. Data from these two areas may indicate whether or not heavier tree damages result when mistletoe and budworm are both present.

All blocks were permanently marked using paint and flagging, witness trees, and corner stakes. Blocks were located to provide a representative sample of three site classes and the past infestations. Three Douglas-fir site trees were measured on each block to determine site index. Site class codes were determined from site index values as follows:

Site class code	
I	site index 75 or above
II	site index 55-74
III	site index 54 or below

When each block was initially established, all conifers (including nonhost species) with a d.b.h. of 5 inches or greater were permanently tagged with block and tree numbers. Trees with a d.b.h. of 5.0 to 8.9 inches were classed as poles, while those with a d.b.h. of 9.0 inches or larger were classed as sawtimber. The following information was obtained from each tree:

1. Species
2. Height (to nearest foot)
3. D.b.h. (to nearest 0.1 inch)
4. Amount of top-kill (length to nearest foot)
5. Condition (live or dead)
6. Crown ratio

In addition, a tally was made in 1981 of all pole- and sawtimber-sized aspen present on the blocks. However, these trees were not permanently tagged.

On each block, a subsample of nine 1/100-acre circular fixed plots were established to assess budworm damage to regeneration-size trees. Plot centers were located on a 90-foot grid in each block (fig. 9, appendix). All trees less than 5 inches in d.b.h. were examined and the following information recorded:

1. Species

2. D.b.h. (to nearest 0.1 inch)

3. Height (to nearest inch)

4. Visual estimate of defoliation (light, medium, or heavy)

5. Condition (live or dead)

Trees were classed as seedlings if d.b.h. was less than 0.5 inches and as saplings if d.b.h. was 0.5 to 4.9 inches.

B. Damage Assessment

1. Defoliation

On each block, 25 Douglas-fir trees, 20 to 40 feet in height, were selected for sampling defoliation in 1978 through 1983. To reduce the effect of sampling on individual trees, only 10 of the 25 were to be sampled each year (i.e., 1978, trees 1-10; 1979, trees 11-20; 1980, trees 21-25 and 1-5; etc.). Two methods were used to estimate defoliation:

a. Visual Method.[1] Each sample tree was divided into three crown levels: upper, middle, and lower. Using binoculars, two observers made independent visual estimates of the percent defoliation of each crown level. These estimates were tallied by recording the midpoint value of the defoliation class in which each estimate belonged. The defoliation classes and midpoint values were as follows:

Defoliation class %	Midpoint value %
0-10	5
11-25	18
26-50	38
51-75	63
76-90	83
91-100	95

[1] Carolin, V. M., and W. K. Coulter. 1972. Sampling populations of western spruce budworm and predicting defoliation on Douglas-fir in eastern Oregon. USDA Forest Serv. Res. Pap. PNW-149. 39 pp.

The two midpoint values for a crown level were averaged and the resultant figure weighted using the following values: Lower crown - 5, middle crown - 3, and upper crown - 1. The average midpoint value multiplied by the assigned weight gave the average defoliation of the crown level.

The sum of the three weighed averages was then divided by 9 to give percent defoliation for the entire tree.

b. Six-class System.[2] This method involved sampling four apical branches: a branch (70 cm in length) from each quadrant at midcrown of each sample tree. On each branch sample, 25 new shoots were examined for current defoliation using the left side of one branch and the right side of another, and so on. Each new shoot was individually examined for defoliation and assigned an index and midpoint value as follows:

Defoliation class %	Index value	Midpoint value
0	0	0
1-25	1	12.5
26-50	2	37.5
51-75	3	62.5
76-99	4	87.5
100	5	100

After index values were determined for the branch samples, individual tree defoliation was calculated using the following formula:

$$\% \text{ defoliation} = \frac{(n_1)\ (12.5) + (n_2)\ (37.5) + (n_3)\ (62.5) + (n_4)\ (87.5) + (n_5)\ (100)}{100}$$

Where n_1 = number of twiglets with index value 1
n_2 = number of twiglets with index value 2
n_3 = number of twiglets with index value 3
n_4 = number of twiglets with index value 4
n_5 = number of twiglets with index value 5

In both the visual method and the 6-class system, block defoliation was simply the average of the individual tree values.

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[2] Parker, D. L., R. E. Acciavatti, and E. D. Lessard. 1978. Western spruce budworm suppression and evaluation project using carbaryl, 1977. Progress Rep. No. 1, USDA Forest Serv., Southwestern Reg. 136 pp.

2. Growth Loss

A major objective of the project is the evaluation of radial growth loss which resulted from past infestations that occurred from 1922-1966, and the current infestation which began in 1975. Work on this objective began with the collection of increment cores in 1978 and 1979. On each block, 2 cores, 90° apart, were taken at d.b.h. from each of 30 sample trees: 10 Douglas-fir, 10 true fir, and 10 ponderosa pine. The core samples were placed in plastic straws for storage, labeled for identification, and sent to the Intermountain Forest and Range Experiment Station, Moscow, Idaho, where radial growth measurements were done on an Addo System.

However, major problems appeared when core data were prepared for a tree-ring analysis computer program. Consultation with the Modern Studies Unit of the University of Arizona's Laboratory of Tree-Ring Research (the world center for dendrochronology) revealed that problems encountered could have been avoided if sufficient information on dendrochronology had been obtained prior to core collection and measurement.

The data obtained from cores collected in 1978 and 1979 cannot be used to analyze past infestations. The primary reason is the cores were not cross-dated[3] prior to measurement. In many instances, the two cores from the same tree contained a different number of rings. The differences were a result of two things: Cores were taken off center and/or they had one or more missing rings. Because cores were stored in plastic, they became rotten and could not be reexamined for cross-dating.

In order to meet the objectives of the project, cores will be collected in 1982 and will be used to analyze the effects of past infestations, as well as those of the current infestation. An agreement has been made with the Laboratory of Tree-Ring Research to do a complete wood-core analysis study. They will collect the cores, date and measure them, check the dating and measurements, put the data through computer analysis, do climatic and insect correlations, and write a final report.

3. Top-kill and Tree Mortality

a. Poles and Sawtimber

In the year of block establishment, all pole- and sawtimber-sized trees were examined for top-kill and tree mortality, and the length of any dead top was estimated to the nearest foot. All

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[3] Cross-dating is the basic technique of modern dendrochronology and through systematic comparison of tree-ring patterns it allows the determination of tree-ring dates which are accurate to the year.

top-kill and tree mortality not attributed to the present infestation were recorded as "old" and will be used as a base line for future damage assessment. All top-kill and tree mortality which could be attributed in whole or in part to the present infestation were recorded as "new."

All trees were reexamined in midsummer each year for new top-kill and mortality and to verify earlier observations. Verification is necessary because it is often difficult to determine top-kill from a single observation due to a tree's ability to establish adventitious buds and refoliate after intense defoliation. Sometimes, a tree's top will be completely defoliated for several consecutive years, with refoliation occurring each year.

In addition to the midsummer examination, another tree condition survey was conducted in May at about the time of bud flush and prior to heavy budworm feeding. Only "top-kill" on which no live buds were observed was recorded. Data from this early examination were used to help verify top-kill observed in midsummer.

When discussing damages, "combined" rather than average figures have been used to describe percent trees affected. The "combined" percentage was obtained by dividing the total number of trees affected on all blocks of a group by the total number of trees which could have been affected on those blocks. For example, the sum was obtained of all Douglas-fir poles on blocks 1 through 12 with confirmed top-kill in 1981; this total was divided by the total number of Douglas-fir poles present on blocks 1 through 12; the result was the percent of Douglas-fir poles with confirmed top-kill on blocks 1 through 12, that is, the "combined" percent.

In 1980 and 1981, blocks were examined by a pathologist to determine if any pathogens were present which could produce or contribute to the occurrence of top-kill and tree mortality. Also, in 1981 (and planned for remaining years of the project), all dead and dying trees were examined to determine if pathogens contributed to or were the primary cause of mortality.

b. Seedlings and Saplings

The condition of seedlings and saplings was checked annually. Data were recorded on tree mortality, top-kill, and defoliation (low, moderate, or heavy).

C. Insect Densities

On each block, 25 Douglas-fir trees, 20 to 40 feet in height, were selected for sampling insect densities. To reduce the effect of sampling on individual trees, only 10 of the 25 were to be sampled each year. These sample trees were the same as those selected for defoliation sampling.

1. Larvae

Sampling was begun when 20 percent of the larvae were in the fifth instar or larger. On each tree, two 15-inch branches were cut from opposite sides of the midcrown using a pole pruner with attached collecting bag. If a sample branch did not have at least 15 live buds, another branch was cut. The length and width of branches were recorded to determine the foliated branch surface area.

Larvae were removed from sample branches, counted, and preserved in ethyl alcohol. Total numbers of larvae and live buds per branch were recorded. Head capsule measurements were taken on a 25-percent subsample to determine instar distribution at time of sampling.

2. Egg Masses

Egg masses were sampled by cutting two 70-cm midcrown branches from opposite sides of each sample tree with a pole pruner. The length and width of branches were measured to calculate foliated branch surface area. Each branch was then individually bagged in a 1/4-bushel paper or cloth sack, transported to the laboratory, and stored at about 40° F prior to examination.

Foliage was examined under ultraviolet light for egg masses. Needles bearing egg masses were classed as from current year's foliage or a previous year's and kept separate in labeled pill boxes. New egg masses, deposited in the year of sampling, were separated under a stereomicroscope from old egg masses deposited in the previous year(s). All egg masses on current year's foliage were classed as new and their characteristics formed the basis for aging those egg masses found on a previous year's foliage.

V. RESULTS AND DISCUSSION

A. Stocking and Composition

In 1981, densities of pole- and sawtimber-sized trees were not much different than they were at time of block establishment and ranged from 68 to 366 trees per acre. With the exception of block 5, which has about 60 percent ponderosa pine, host species for the budworm are most abundant.

Douglas-fir is the predominant host species, making up 10.9 to 82.5 percent of the pole- and sawtimber-sized trees on each block. Pole-sized trees are more prevalent than sawtimber-sized trees on nine of the blocks, while the reverse is true only for block 5. On the remaining seven blocks, the stands are composed of approximately equal numbers of pole- and sawtimber-sized trees. Refer to table 2, appendix, for stocking densities by species and size class.

The numbers of trees less than 5 inches in diameter (and ≧ 12 inches in height) found on the nine 1/100-acre sample plots on each block were converted to a per acre basis (table 3, appendix). Total numbers of trees range from a low of 577 trees per acre on block 15 to a high of 3,089 trees per acre on block 1. Host species comprise 34.6 to 100 percent of all regeneration-sized trees, and on all but 3 blocks, they comprise more than 60 percent. True firs are the most abundant host species. Seedlings are more abundant than saplings on all but two blocks. On block 6, trees are divided equally between the two size classes, while on block 7, saplings comprise 81.1 percent of the regeneration.

Stocking levels from 1978 to 1981 of host seedlings less than 1 foot in height are shown in table 4, appendix. Changes in stocking levels since 1978/1979 have been variable from block to block.

B. Damage Assessment

In the following discussion, the assessment blocks have been placed in three groups based on time of initial infestation: (1) Blocks 1 through 12 (prior to 1978), (2) blocks 13 and 16 (1979), and (3) block 17 (1980).

1. Defoliation

Defoliation estimates for pole- and sawtimber-sized Douglas-fir from 1978 through 1981 are shown in table 5, appendix. On blocks 1 through 12, where 4 years of data have been collected, the overall average defoliation increased from 1978 to 1979, stayed about the same level in 1980, and then increased slightly in 1981: 6-class system, 52.5, 82.3, 82.9, and 85.6 percent; visual method, 41.0, 79.9, 79.8, and 84.7 percent.

When defoliation data (6-class system) from blocks 1 through 12 were grouped by site class, the following average percentages were obtained:

Site class	1978	1979	1980	1981
I	51.6	66.6	84.5	76.6
II	64.0	89.8	81.3	91.2
III	38.8	76.2	82.5	93.2

No consistent pattern of highest defoliation is observed for a site class. However, it is apparent that site class II blocks have sustained the greatest amount of defoliation through time when cumulative and average yearly defoliation percentages are determined:

Site class	Cumulative 1978-81%	1978-81 Average %
I	279.3	69.8
II	326.3	81.6
III	290.7	72.7

With the 6-class system, average defoliation on blocks 13 through 16 (which became infested with budworm in 1979) more than tripled each year from 1979 to 1981: 7.8 to 26.1 to 91.8 percent. With the visual method, defoliation showed an increase each year, but did not change much until 1981: 5.0 to 7.8 to 88.7 percent.

Block 17 became infested with budworm in 1980. Visual defoliation remained at 5 percent from 1979 to 1981 (remember, a 5-percent rating represents 0-10 percent defoliation); however, the 6-class defoliation index increased from 0 percent in 1979 to 25.7 percent in 1980, and 27.2 percent in 1981.

2. Growth Loss

Results of the growth loss aspects of the project will be reported in 1983 when the University of Arizona's Laboratory of Tree-Ring Research completes its study.

3. Top-kill and Tree Mortality

In the following discussion and related tables, top-kill is classed as apparent or confirmed. Apparent top-kill includes trees with any top damage from bare, completely defoliated tops (new top-kill) to spiketops. Trees which have failed to refoliate in successive years are classed as confirmed top-kill. Top-kill data are limited to include only those trees with a minimum top-kill height as follows: One foot for poles and sawtimber, 6 inches for saplings, and 1 inch for seedlings. In addition, confirmed top-kill and tree mortality data are always cumulative; that is, 1981 mortality includes trees killed in 1978, 1979, 1980, and 1981.

a. Top-kill of Poles and Sawtimber

Examination of top-kill data for poles and sawtimber (tables 6 and 7, appendix) shows similar damage trends have occurred in both size classes; however, poles consistently sustained a higher level of damage.

Blocks 1 through 12. For both pole- and sawtimber-sized trees on blocks 1 through 12, combined apparent top-kill increased from 1978 to 1980 and decreased in 1981. Less than 50 percent of apparent top-kill found each year was later verified. Confirmed top-kill of poles increased from 0.2 percent in 1978 to 7.3 percent in 1980; confirmed top-kill of sawtimber-sized trees increased from 0 in 1978 to 5.3 in 1980.

Top-kill among the three host types has been variable. On plots 1 through 12, spruce poles showed the highest amount of apparent top-kill, while Douglas-fir poles showed the least. However, confirmed top-kill of pole-sized trees has been approximately the same on both true fir and spruce. Douglas-fir poles had more confirmed top-kill than true fir and spruce in 1978, but dropped behind these two hosts in 1979 and 1980:

Percent confirmed top-kill of poles

	1978	1979	1980
Douglas-fir	0.3	2.6	6.3
True fir	0	5.2	10.4
Spruce	0	5.6	10.3

In the sawtimber-size class, true fir had the highest combined occurrence of apparent top-kill. Also, true fir had the greatest amount of comfirmed top-kill, while Douglas-fir had the least:

Percent confirmed top-kill of sawtimber

	1978	1979	1980
Douglas-fir	0	0.6	3.6
True fir	2.8	5.6	8.3
Spruce	0	5.3	5.3

When blocks 1 through 12 were grouped by site class, no direct correlation could be made between the percent of top-kill occurrence and site class.

Blocks 13 through 16. Only a small amount of top-kill has occurred on blocks 13 through 16, which first became infested with budworm in 1979. Apparent top-kill has increased some each year from 1979 to 1981. Confirmed top-kill first appeared in 1980 and was limited to 0.4 percent of the sawtimber-sized trees.

Apparent top-kill on the Osha Mountain blocks was highest on true fir poles. Only a small percent of the Douglas-fir and spruce poles, as well as Douglas-fir sawtimber-sized trees, have had apparent top-kill; only a small percentage of trees sustained confirmed top-kill--0.5 percent of Douglas-fir sawtimber in 1981.

Block 17. On block 17, where budworm first appeared in 1980, 1.0 percent of the poles showed apparent top-kill in 1980; no confirmed top-kill was observed. No top-kill of Douglas-fir and true fir has yet occurred, and only 5.6 percent of spruce poles had apparent top-kill in 1980.

b. Tree Mortality of Poles and Sawtimber

No mortality of pole- and sawtimber-sized trees was found in 1978 (table 8, appendix). By August 1981, a total of 18 pole- and sawtimber-sized trees had died, out of a total of 1,626 host trees. Combined mortality for blocks 1 through 12 was 0.3, 0.5, and 0.8 percent for poles in 1979, 1980, and 1981, respectively, and 0.7, 0.7, and 1.0 percent for sawtimber-sized trees in the same years. On the Osha Mountain blocks, mortality was 0, 0.2, and 0.4 percent for poles in 1979, 1980, and 1981, respectively; no sawtimber-sized trees have died. Also, no mortality of poles or sawtimber has occurred on the Burned Mountain block.

Examination of the blocks revealed the presence of several pathogens which cause tree mortality regardless of the presence of budworm (table 9). A total of 18 pole- and sawtimber-sized host trees died on the 17 blocks. Spruce budworm defoliation was probably not the primary cause of death for most, if not all, of these trees (table 10, appendix). For instance, five of the six trees which have died in La Jara Canyon had extensive root rot and/or had been windthrown. On block 16, defoliation remained below 10 percent until 1981, so it is highly improbable that budworm contributed in any way to the mortality of the spruce pole found dead in 1980. However, it seems probable that, in areas which have sustained heavy defoliation for several consecutive years, budworm defoliation has further stressed trees already weakened by root rot or dwarf mistletoe and hastened their death.

c. Top-kill of Seedlings and Saplings

Blocks 1 through 12. Top-kill of seedlings and saplings is shown in tables 11 and 12, appendix. On blocks 1 through 12, saplings initially sustained more top-kill; however, by 1981, seedlings had received more damage. An interesting trend is apparent when top-kill data for the four size classes are compared:

	Apparent top-kill				Confirmed top-kill		
	1978	1979	1980	1981	1978	1979	1980
Seedlings	0	3.2	19.3	30.9	0	2.7	12.3
Saplings	0	6.1	13.0	21.5	0	4.7	10.3
Poles	2.2	8.1	16.5	15.0	0.2	3.3	7.3
Sawtimber	2.8	4.5	18.7	9.5	0.3	1.7	4.3

Initial top-kill occurred in overstory trees where early outbreak budworm populations were concentrated. As the outbreak progressed, higher density larval populations apparently dispersed to seedling- and sapling-size classes where top-kill occurs rapidly and more severely than on overstory trees.

By 1981, the three tree species had approximately equal percentages of seedlings with confirmed top-kill. However, true fir saplings had sustained one-third to one-half the amount of confirmed top-kill found on Douglas-fir and spruce saplings:

	Percent confirmed top-kill		
	1978	1979	1980
Douglas-fir	0	7.1	15.4
True fir	0	2.5	5.0
Spruce	0	3.7	11.1

Blocks 13 through 16. On blocks 13 through 16, seedlings had the highest amount of apparent and confirmed top-kill in 1979 and 1980; and saplings sustained more apparent top-kill in 1981, with 15.3 percent of them affected compared to 13.1 percent of the seedlings. Among the three tree species, only true fir seedlings and saplings have sustained confirmed top-kill.

Block 17. On the Burned Mountain block, 13.3 percent of the true fir seedlings had apparent top-kill in 1980. However, no occurrence of apparent or confirmed top-kill was observed in 1981. Because of this fact and because of the very low budworm population present on block 17, it is possible that some agent besides budworm was responsible for the apparent top-kill.

d. Mortality of Seedlings and Saplings.

A comparison of size classes shows that seedlings have sustained a higher average mortality than saplings on the original 12 blocks and the Osha Mountain blocks (tables 11 and 12, appendix). Results are variable when species mortality is compared between the two groups of blocks. Average percent mortality for 1981 by species and size classes was as follows:

	Seedlings			Saplings		
Blocks	DF	TF	SP	DF	TF	SP
1-12	8.3	6.8	3.4	2.1	2.5	0
13-16	5.3	3.0	16.7	0	1.4	0

The only similarity in mortality between blocks 1 through 12 and the Osha Mountain blocks is that true fir had the highest mortality in the sapling-size class in both groups of blocks.

When data for blocks 1 through 12 were grouped by site class, Douglas-fir and true fir appeared to have sustained heavier damages in the lower site classes. Spruce, on the other hand, appeared to have received more damage in the higher site classes.

No mortality of seedlings or saplings has occurred on the Burned Mountain block.

C. Insect Densities

For blocks 1 through 12, larval densities averaged 25.4, 16.5, and 17.3 larvae per 100 buds in 1979, 1980, and 1981, respectively. These larval densities resulted in similar amounts of defoliation each year from 1979 to 1981: 82.3, 82.9, and 85.6 percent.

Average egg mass densities increased from 1978 to 1980: 20.6, 37.8, and 58.6 egg masses per m^2, and then decreased in 1981 to 23.7 egg masses per m^2. This decrease in density does not necessarily mean the infestation is collapsing. There were still sufficient numbers of egg masses on all but block 3 to result in larval densities and defoliation levels in 1982 equivalent to those of the past 3 years.

Larval and egg mass densities continued to increase on the Osha Mountain and Burned Mountain blocks. Compared to 1980 larval densities, those in 1981 at least tripled on Osha Mountain (4.8 to 17.5 larvae per 100 buds) and on Burned Mountain (0.8 to 2.4 larvae per 100 buds). Egg mass densities on Osha Mountain were 11.3, 16.4, and 23.1 egg masses per m^2 from 1978 to 1981, respectively, and those on Burned Mountain increased from 0 in 1979 to 1.8 and 8.5 egg masses per m^2 in 1980 and 1981. Larval and egg mass densities are expected to increase in 1982 on the Osha Mountain and Burned Mountain blocks, and defoliation will remain the same or increase in both areas.

VI. CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Damage assessment plots installed shortly after the detection of the budworm outbreak have sustained damage. Measurable budworm-caused damage appeared on plots approxmately 3 to 4 years after the outbreak was detected. Seedling- and sapling-sized trees have sustained greater top-kill than pole- and sawtimber-size trees thus far in the outbreak. Pole and sawtimber tree mortality to date has been negligible and not solely attributed to budworm defoliation. Seedling and sapling mortality has shown annual increases from 1979 to 1981.

During 1979 to 1981, larval densities on blocks 1 through 12 remained within a range of 16.4 to 25.4 larvae per 100 buds. Egg mass densities on the same blocks ranged from 20.7 to 58.6 per m^2 foliage. Defoliation (6-class system) during the same period ranged from 82.3 to 85.6 percent of the new growth.

Damage assessment data, to date, have some management implications. Measurable tree damage (principally top-kill) occurs only after at least 3 years of defoliation. This fact allows managers an evaluation and planning "window" to address the budworm problem. Pole and sawtimber tree mortality may not occur until well into the outbreak cycle (possibly 5 or more years). However, seedling and sapling mortality begins after as little as 3 years of defoliation. Again, this fact, depending on management objectives, may influence suppression decisions.

VII. PLANS FOR FY 1982

Data will continue to be collected on defoliation, tree damages and losses, and insect densities.

LITERATURE CITED

Anonymous. 1977. Tales the tree rings tell. MOSAIC. Vol. 8, No. 5.

Ferguson, C. W. 1970. Concepts and techniques of dendrochronology in Scientific methods in medieval archaeology. R. Berger, ed. UCLA Center for Medieval and Renaissance Studies Contributions:IV. Univ. of Calif. Press. Berkeley, Los Angeles, London. Pp. 183-200.

APPENDIX

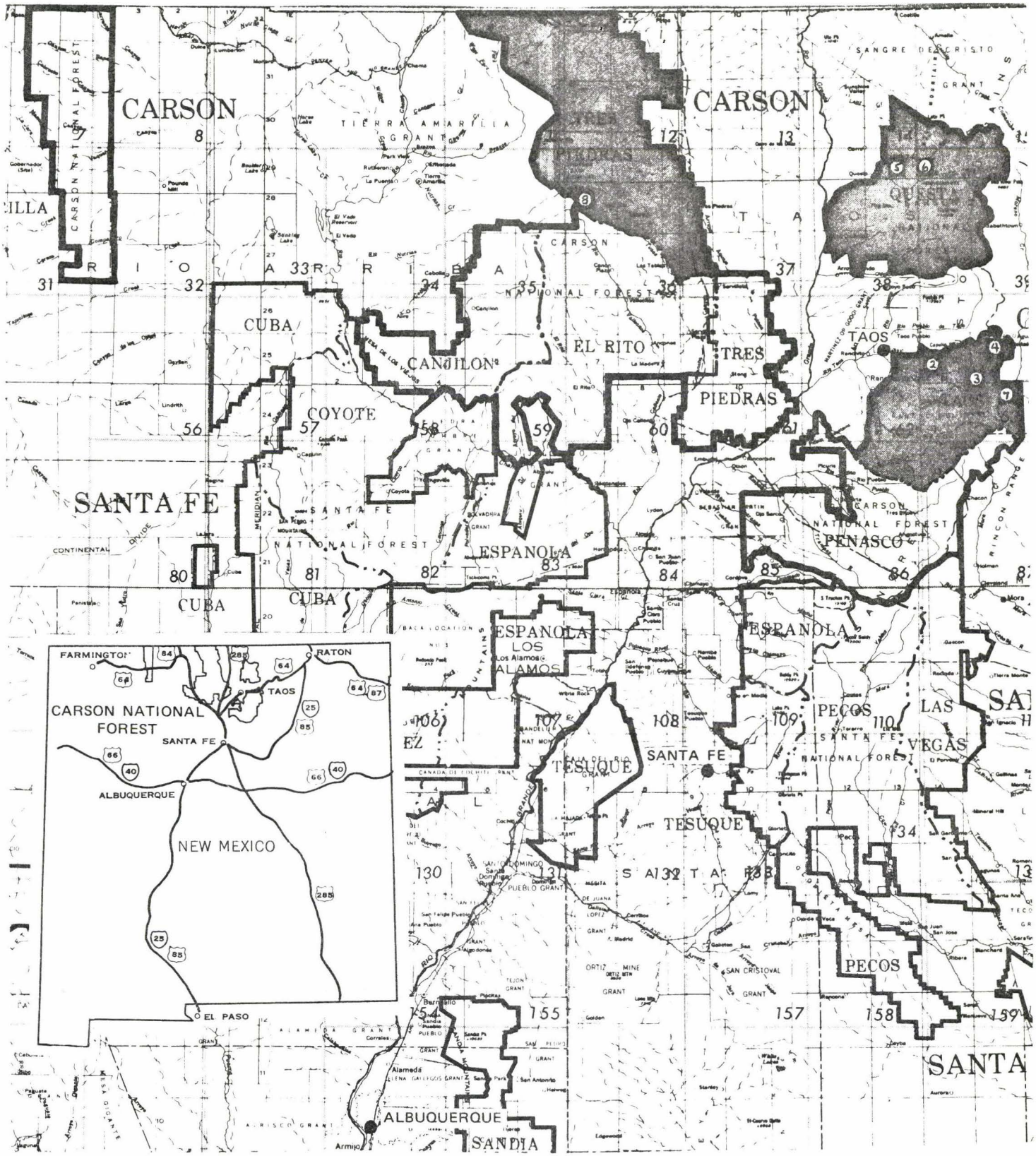


Figure 1. General location of evaluation blocks for the Spruce Budworm Damage Assessment Project on the Tres Piedras, Questa, and Taos Ranger Districts, Carson National Forest, 1978-81. Numbers (2 - 8) indicate subsequent maps (Figures 2-8) which show specific locations of 17 evaluation blocks.

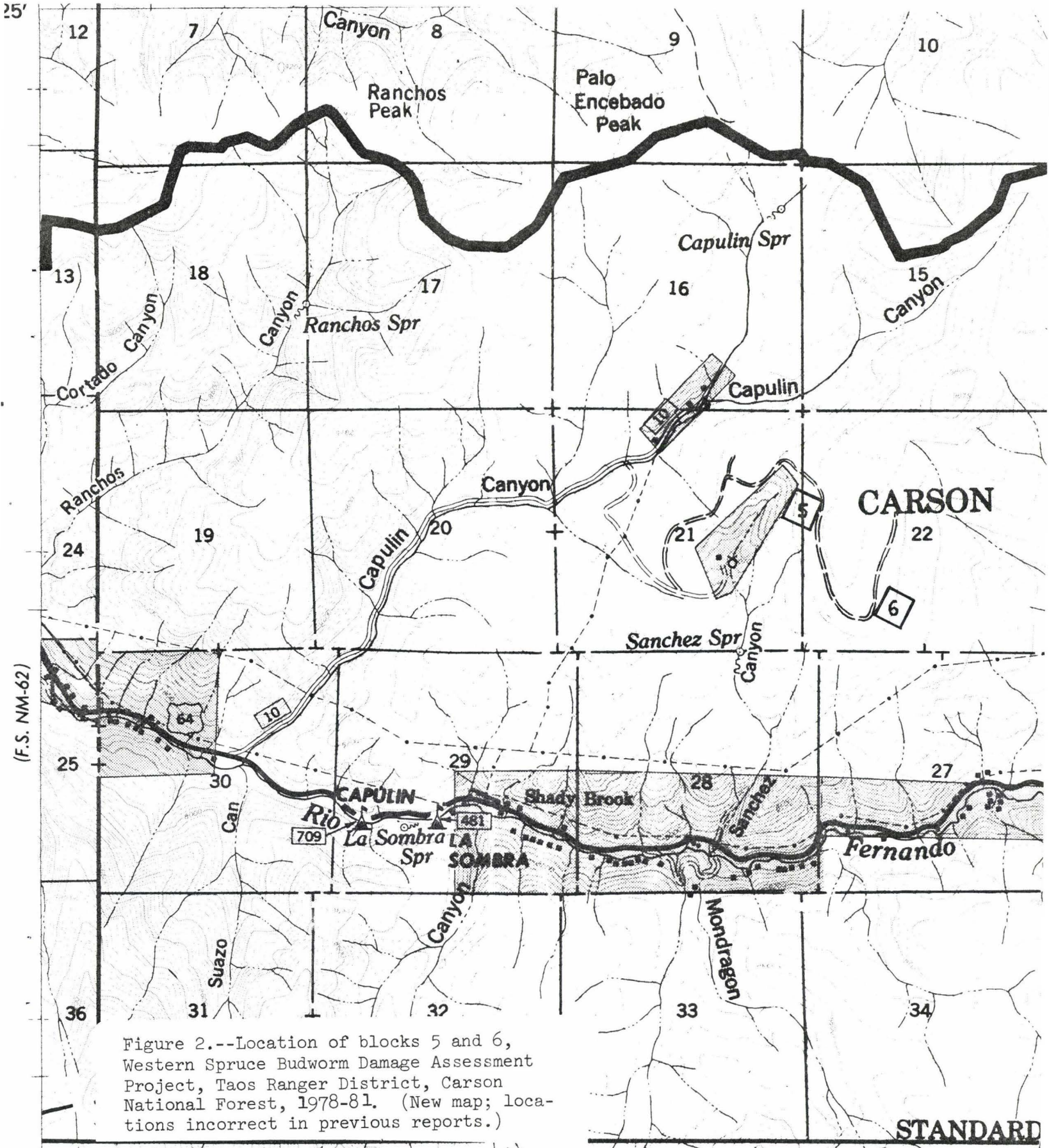


Figure 2.--Location of blocks 5 and 6, Western Spruce Budworm Damage Assessment Project, Taos Ranger District, Carson National Forest, 1978-81. (New map; locations incorrect in previous reports.)

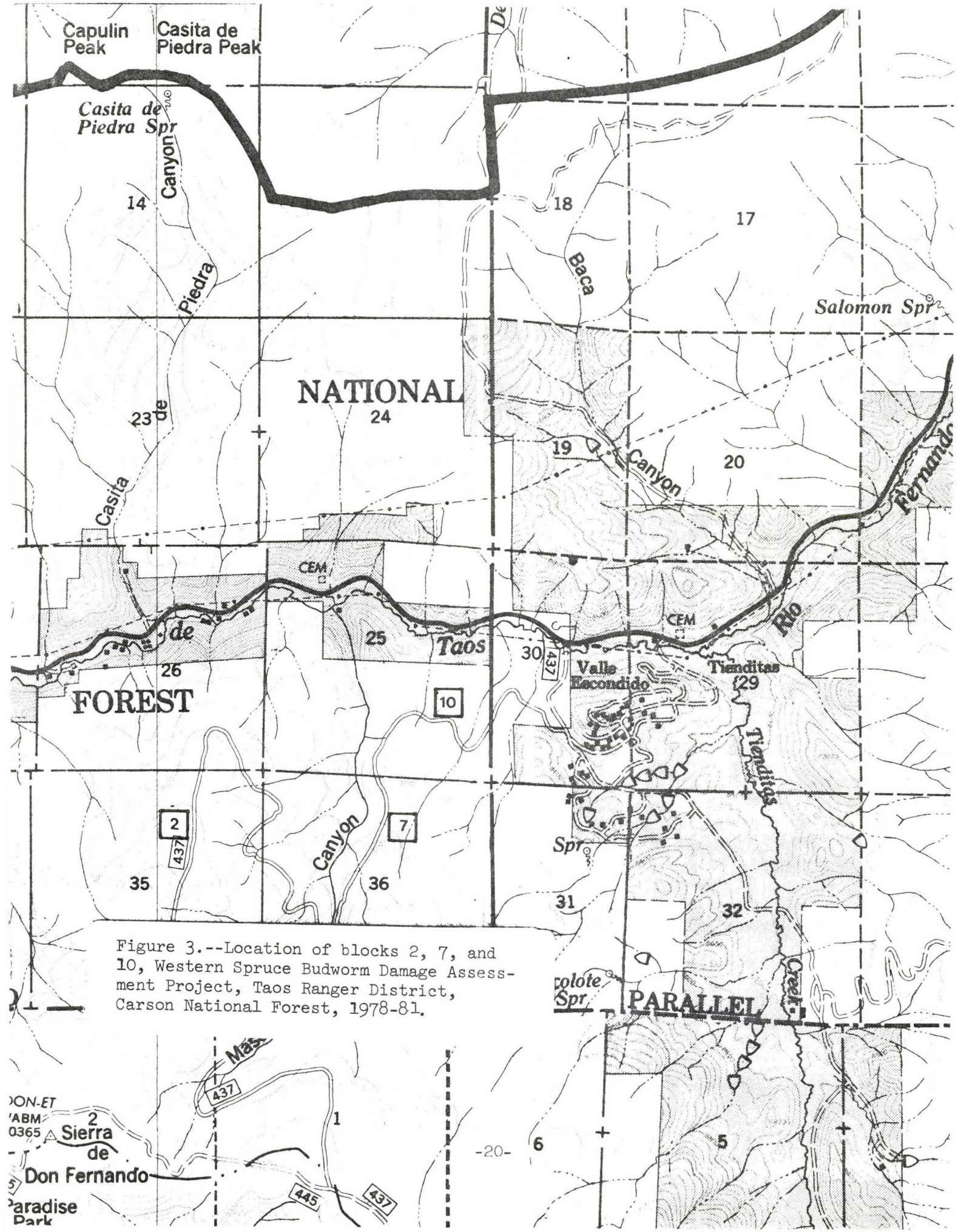


Figure 3.--Location of blocks 2, 7, and 10, Western Spruce Budworm Damage Assessment Project, Taos Ranger District, Carson National Forest, 1978-81.

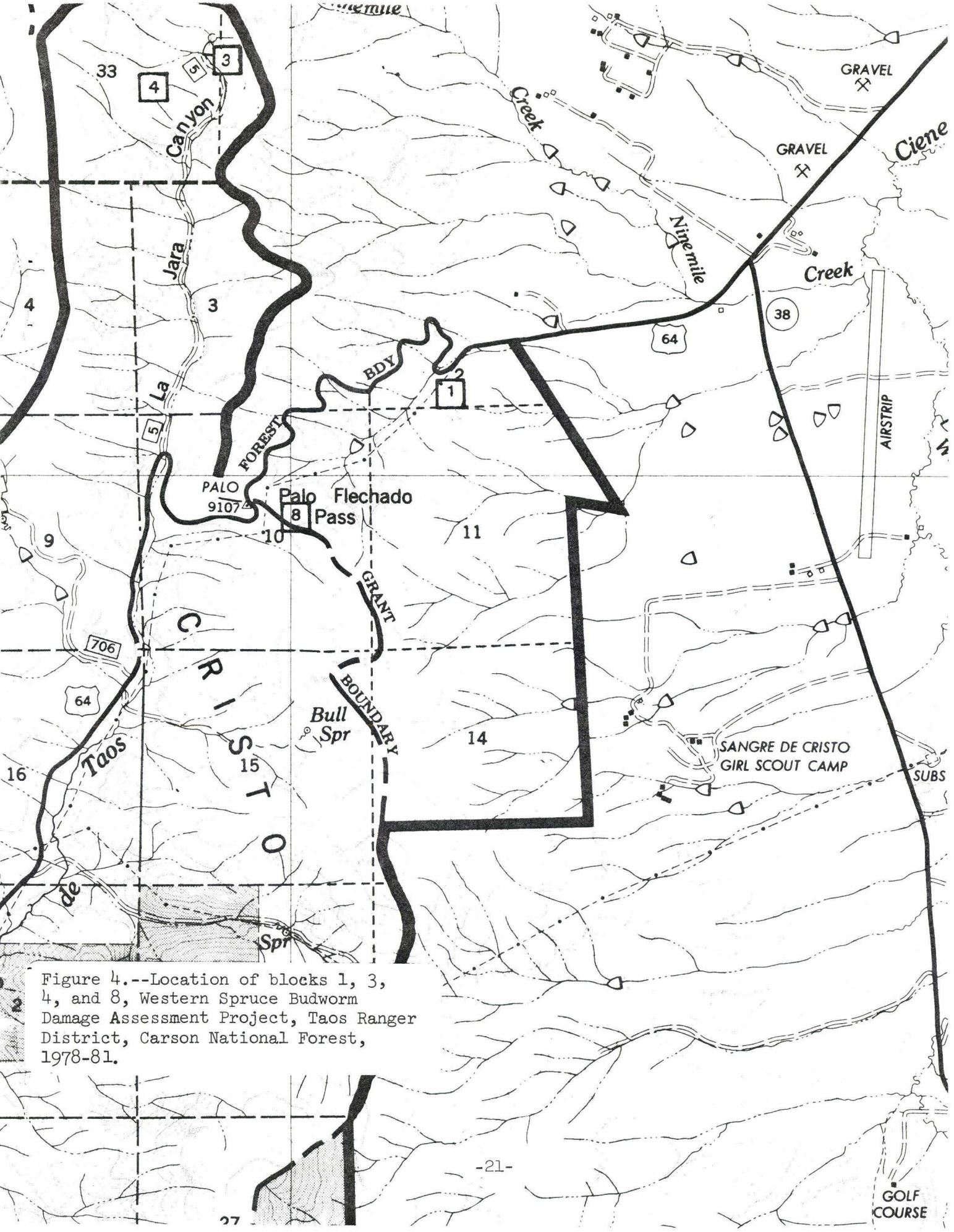


Figure 4.--Location of blocks 1, 3, 4, and 8, Western Spruce Budworm Damage Assessment Project, Taos Ranger District, Carson National Forest, 1978-81.

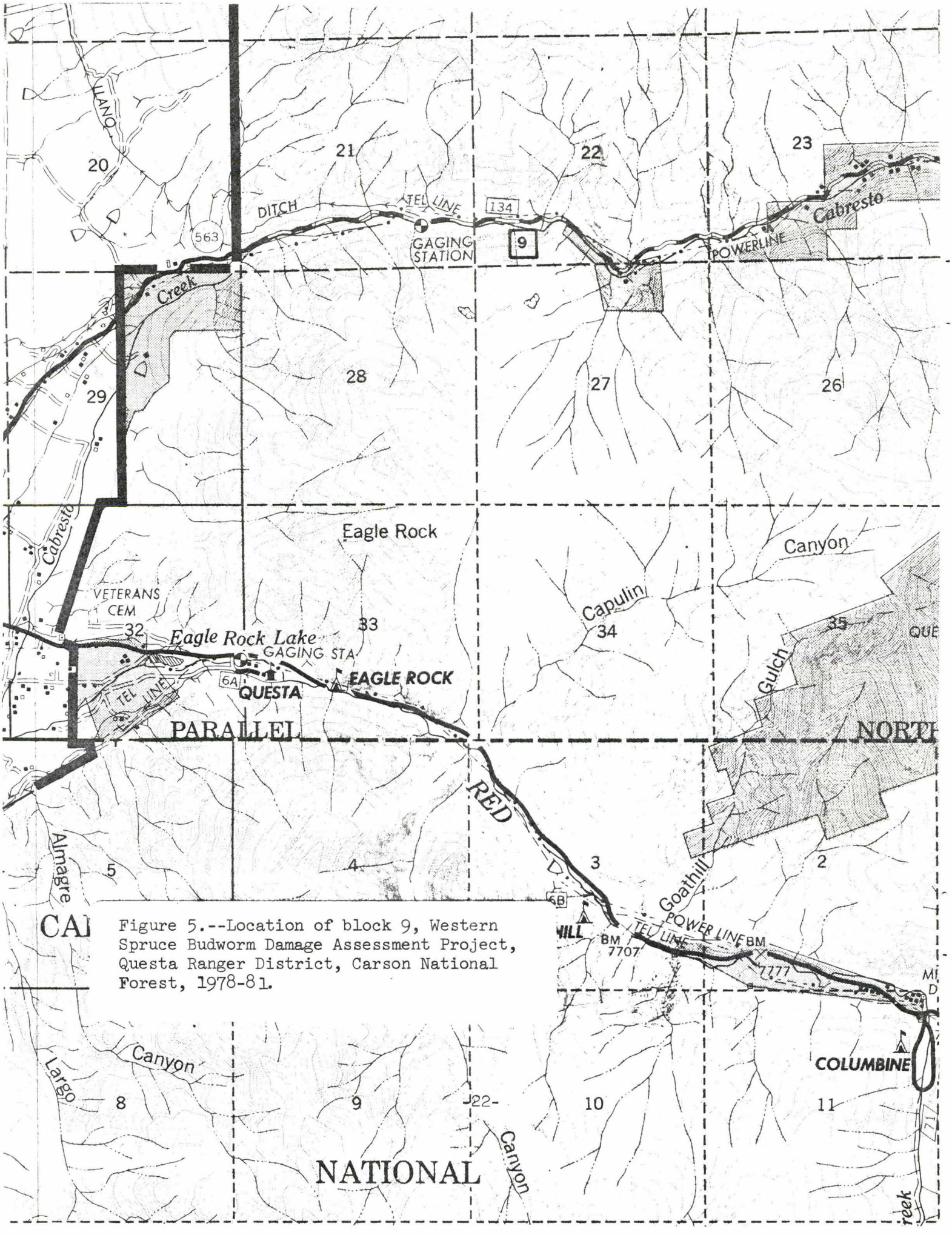


Figure 5.--Location of block 9, Western Spruce Budworm Damage Assessment Project, Questa Ranger District, Carson National Forest, 1978-81.

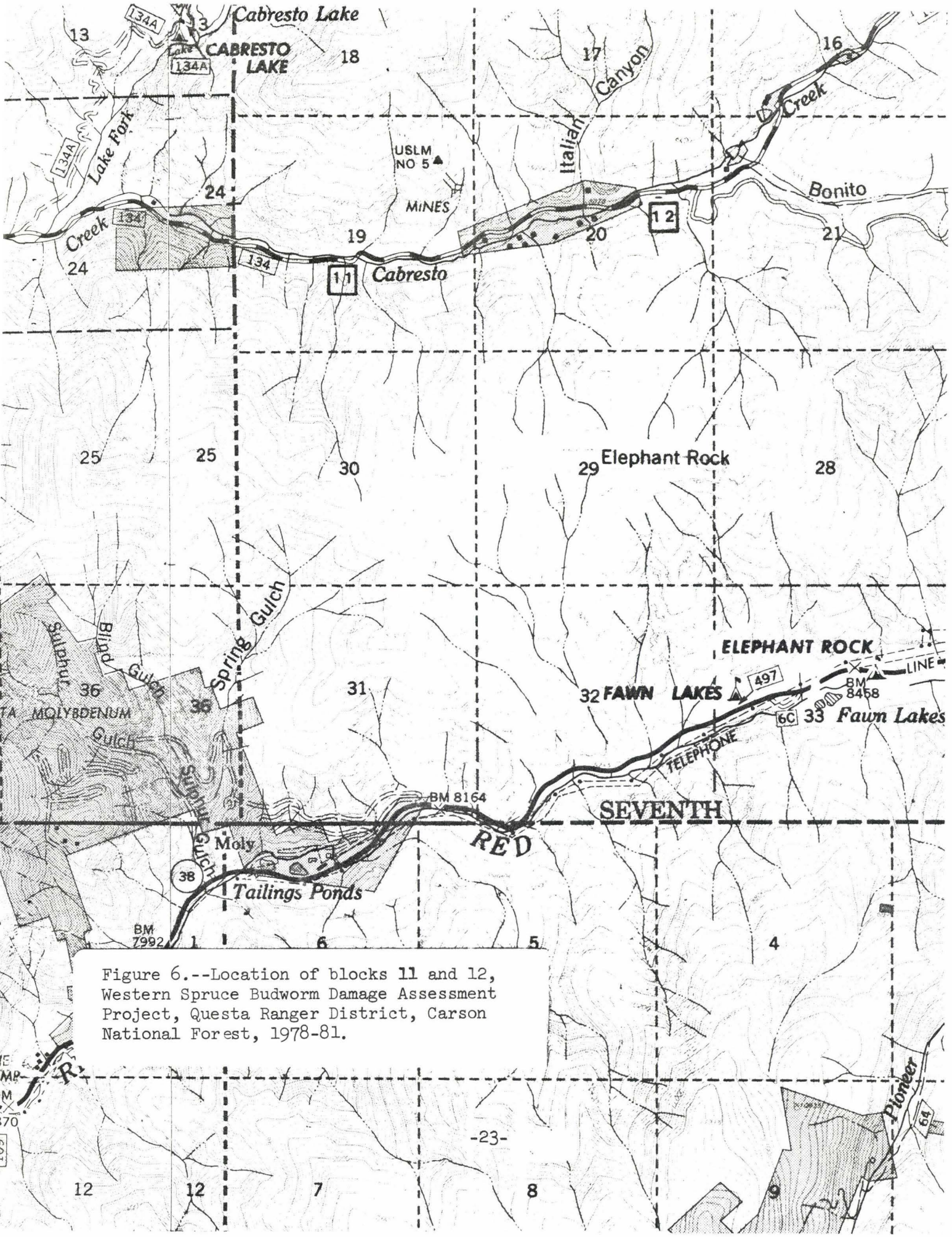


Figure 6.--Location of blocks 11 and 12, Western Spruce Budworm Damage Assessment Project, Questa Ranger District, Carson National Forest, 1978-81.

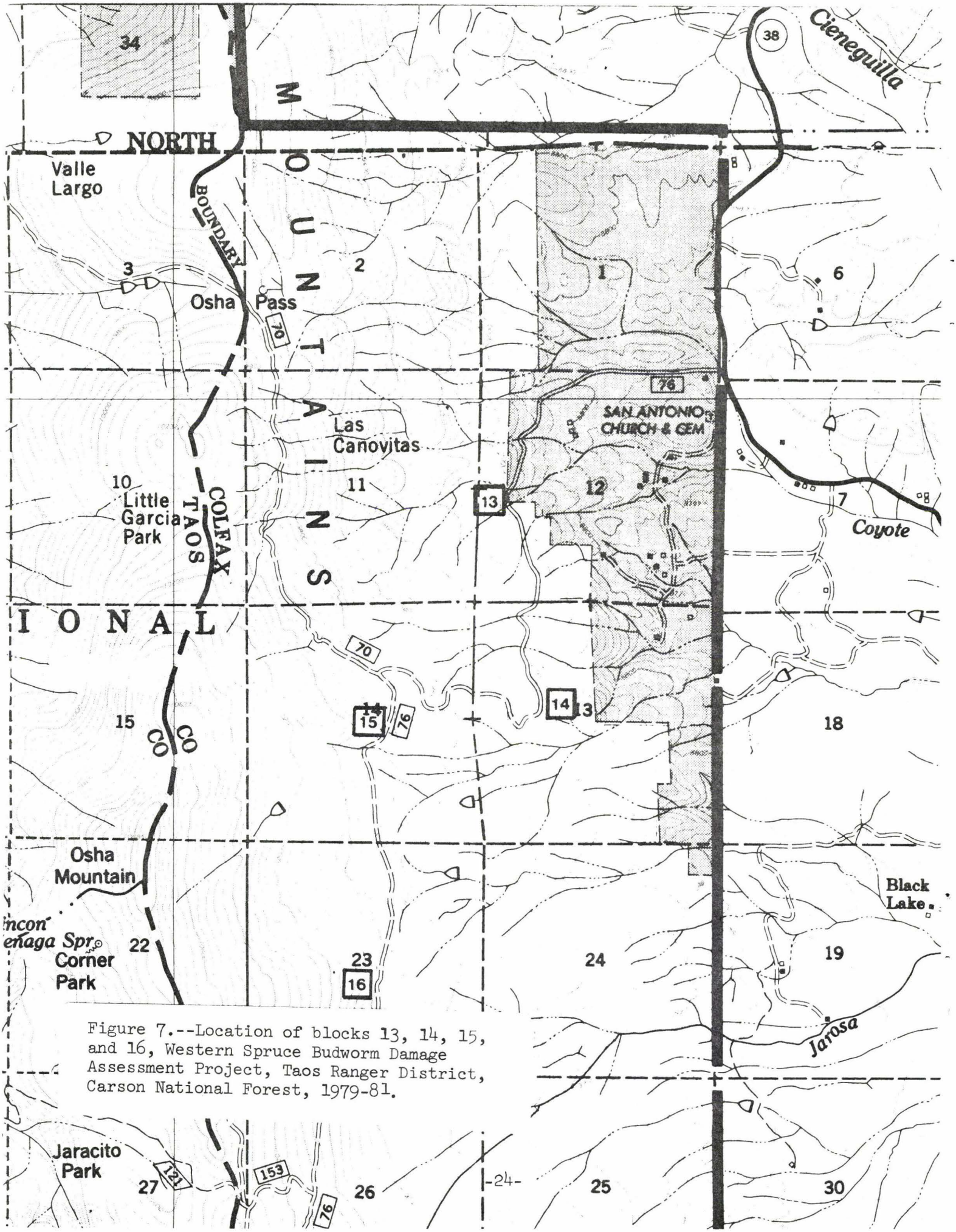


Figure 7.--Location of blocks 13, 14, 15, and 16, Western Spruce Budworm Damage Assessment Project, Taos Ranger District, Carson National Forest, 1979-81.

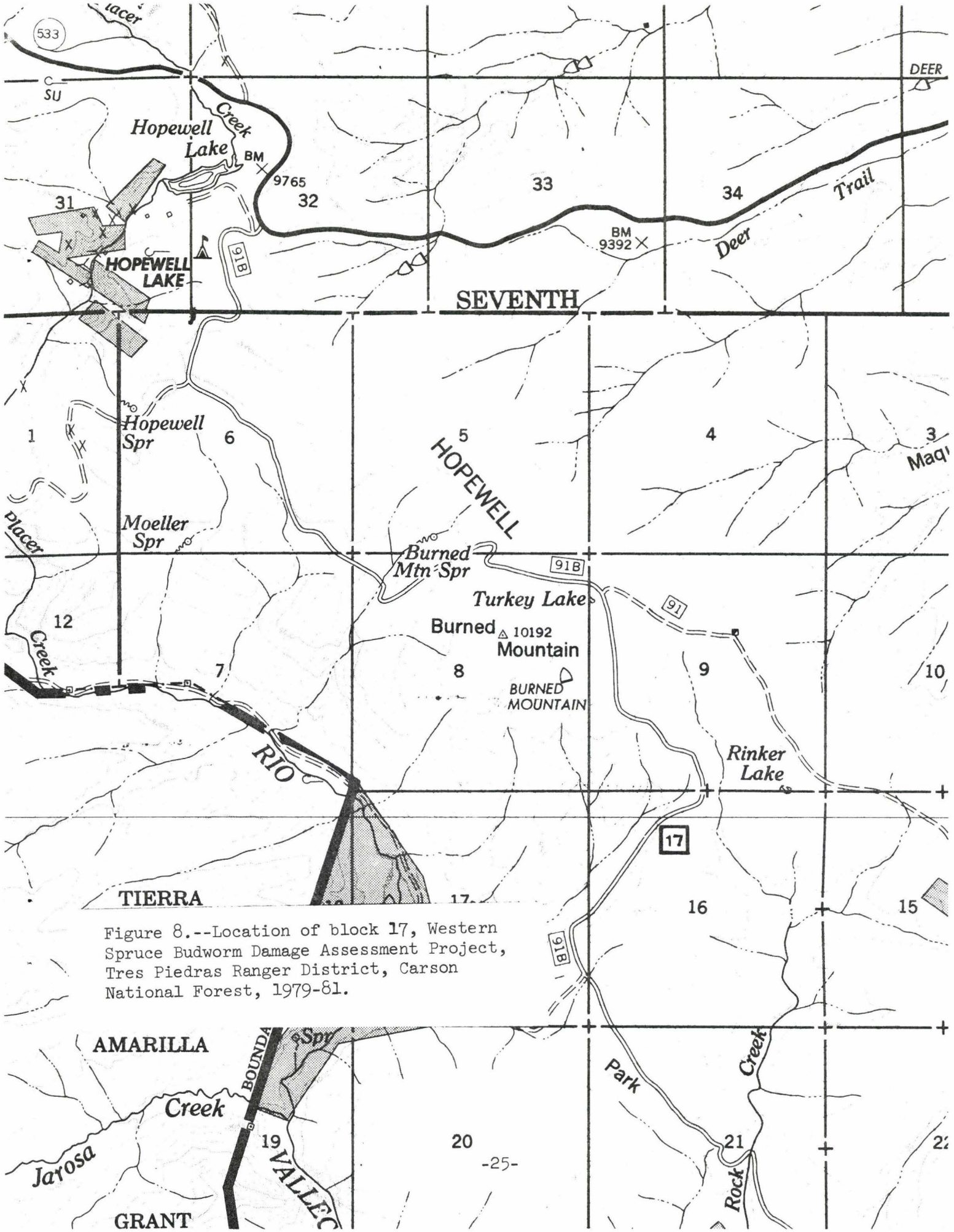
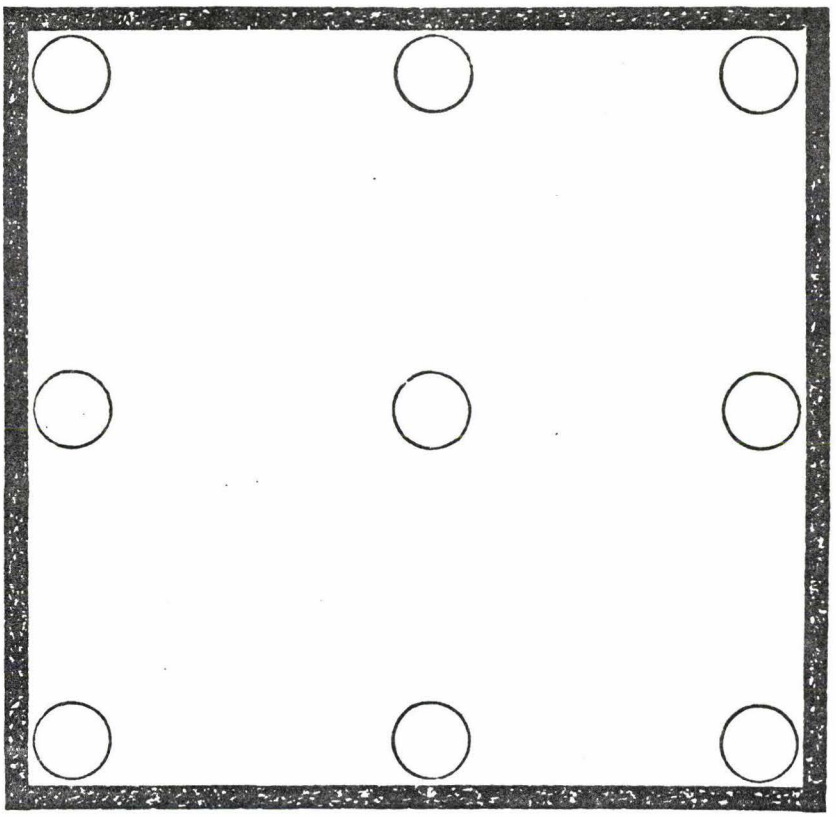


Figure 8.--Location of block 17, Western Spruce Budworm Damage Assessment Project, Tres Piedras Ranger District, Carson National Forest, 1979-81.

Figure 9.--Layout of 1/100-acre circular plots on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81.

Scale is 2" = 100'



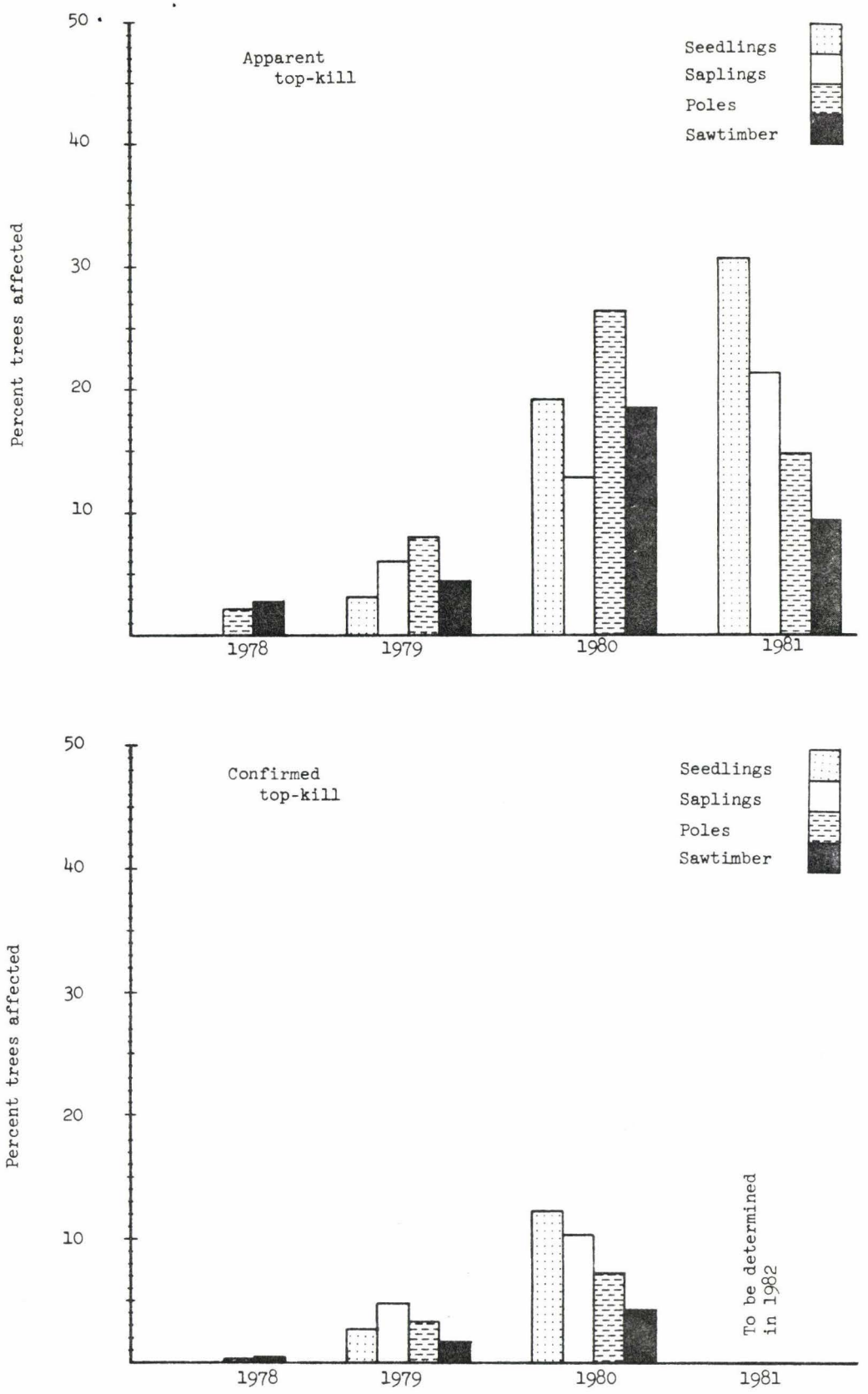


Figure 10.--Apparent and confirmed top-kill of host trees (Douglas-fir, true fir, and spruce) observed in four timber-size classes during Western Spruce Budworm Damage Assessment Project, Carson National Forest, 1978-1981.

TABLE 1.--Douglas-fir site index and class for 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81

Ranger District	Location	Block	Site index	Site class
Taos	Capulin Canyon	5	80	I
		6	50	III
Taos	Garcia Park	2	50	III
		7	60	II
		10	60	II
Taos	La Jara Canyon	3	70	II
		4	80	I
Taos	Palo Flechado Pass	1	50	III
		8	70	II
Questa	Cabresto Canyon	9	80	I
		11	90	I
		12	80	I
Taos	Osha Mountain	13	70	II
		14	60	II
		15	60	II
		16	80	I
Tres Piedras	Burned Mountain	17	60	II

TABLE 2.--Species composition and stocking levels of pole- and sawtimber-sized trees on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, 1978-81 [1] [2] [3]

Location & block	Size class	Douglas-fir (DF)		True fir (TF)		Spruce (SP)		Pine		Aspen		Total host (DF, TF, SP)		Total, all species	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Capulin Canyon															
5	Poles	2	13.3	3	20.0	0	.0	10	66.7	0	.0	5	33.3	15	20.6
	Sawtimber	19	32.8	5	8.6	0	.0	34	58.6	0	.0	24	41.4	58	79.4
	Total	21	28.8	8	10.9	0	.0	44	60.3	0	.0	29	39.7	73	
6	Poles	13	43.3	14+[2]	46.7	0	.0	3-[1]	10.0	0	.0	27	90.0	30	44.1
	Sawtimber	16	42.1	8	21.1	0	.0	14	36.8	0	.0	24	63.2	38	55.9
	Total	29	42.6	22	32.4	0	.0	17	25.0	0	.0	51	75.0	68	
Garcia Park															
2	Poles	126-[3]	75.4	8	4.8	1	0.6	2	1.2	30	18.0	135	80.8	167	65.0
	Sawtimber	72-[1]	80.0	7	7.8	0	.0	10	11.1	1	1.1	79	87.8	90	35.0
	Total	198	77.0	15	5.8	1	0.4	12	4.7	31	12.1	214	83.3	257	
7	Poles	137-[1]	87.3	4	2.5	0	.0	16	10.2	0	.0	141	89.8	157	62.3
	Sawtimber	71	74.7	2	2.1	0	.0	22	23.2	0	.0	73	76.8	95	37.7
	Total	208	82.5	6	2.4	0	.0	38	15.1	0	.0	214	84.9	252	
10	Poles	59	42.8	14	10.1	1	0.7	36	26.1	28	20.3	74	53.6	138	68.0
	Sawtimber	24	36.9	6	9.2	1	1.5	25	38.5	9	13.8	31	47.7	65	32.0
	Total	83	40.9	20	9.8	2	1.0	61	30.1	37	18.2	105	51.7	203	
La Jara Canyon															
3	Poles	16+[1]-[1]	34.8	11-[1]	23.9	18+[2]	39.1	0	.0	1	2.2	45	97.8	46	44.2
	Sawtimber	29-[1]	50.0	2	3.5	25-[3]	43.1	1	1.7	1	1.7	56	96.6	58	55.8
	Total	45	43.3	13	12.5	43	41.3	1	1.0	2	1.9	101	97.1	104	
4	Poles	26	45.6	5	8.8	26	45.6	0	.0	0	.0	57	100.0	57	44.9
	Sawtimber	50	71.4	0	.0	10	14.3	1	1.4	9	12.9	60	85.7	70	55.1
	Total	76	59.8	5	3.9	36	28.4	1	0.8	9	7.1	117	92.1	127	
Palo Flechado Pass															
1	Poles	90	55.9	47-[1]	29.2	6	3.7	0	.0	18	11.2	143	88.8	161	75.6
	Sawtimber	31	59.6	15-[1]	28.9	2	3.8	2	3.8	2	3.8	48	92.3	52	24.4
	Total	121	56.8	62	29.1	8	3.8	2	0.9	20	9.4	191	89.7	213	
8	Poles	60	62.5	5	5.2	1	1.0	15-[1]	15.6	15	15.6	66	68.8	96	50.8
	Sawtimber	59	63.4	13	14.0	0	.0	12	12.9	9	9.7	72	77.4	93	49.2
	Total	119	63.0	18	9.5	1	0.5	27	14.3	24	12.7	138	73.0	189	
Cabresto Canyon															
9	Poles	61	87.1	2	2.9	0	.0	7	10.0	0	.0	63	90.0	70	52.2
	Sawtimber	33	51.6	2	3.1	0	.0	29	45.3	0	.0	35	54.7	64	47.8
	Total	94	70.1	4	3.0	0	.0	36	26.9	0	.0	98	73.1	134	
11	Poles	56-[1]	30.9	12	6.6	15	8.3	0	.0	98	54.1	83	45.9	181	80.1
	Sawtimber	28	62.2	8	17.8	7	15.6	1	2.2	1	2.2	43	95.6	45	19.9
	Total	84	37.2	20	8.9	22	9.7	1	0.4	99	43.8	126	55.8	226	
12	Poles	81+[4]	44.3	7-[1]	3.8	39	21.3	0	.0	56	30.6	127	69.4	183	69.3
	Sawtimber	37	45.7	3	3.7	9	11.1	1	1.2	31	38.3	49	60.5	81	30.7
	Total	118	44.7	10	3.8	48	18.2	1	0.4	87	33.0	176	66.7	264	
Osha Mountain															
13	Poles	107	70.4	7	4.6	3	2.0	0	.0	35	23.0	117	77.0	152	74.9
	Sawtimber	45	88.2	1	2.0	0	.0	0	.0	5	9.8	46	90.2	51	25.1
	Total	152	74.9	8	3.9	3	1.5	0	.0	40	19.7	163	80.3	203	
14	Poles	49	39.2	33+[2]	26.4	4	3.2	31+[1]	24.8	8	6.4	86	68.8	125	61.6
	Sawtimber	36	46.1	25	32.1	0	.0	17	21.8	0	.0	61	78.2	78	38.4
	Total	85	41.9	58	28.6	4	2.0	48	23.7	8	3.9	147	72.4	203	
15	Poles	32+[2]	27.1	16+[2]	13.6	46+[1]	39.0	0	.0	24	20.3	94	79.7	118	56.5
	Sawtimber	79	86.8	3	3.3	9	10.0	0	.0	0	.0	91	100.0	91	43.5
	Total	111	53.1	19	9.1	55	26.3	0	.0	24	11.5	185	88.5	209	
16	Poles	16	5.3	50	16.7	182+[1]-[1]	60.7	0	.0	52	17.3	248	82.7	300	82.0
	Sawtimber	24	36.4	4	6.1	36	54.5	0	.0	2	3.0	64	97.0	66	18.0
	Total	40	10.9	54	14.7	218	59.6	0	.0	54	14.7	312	85.2	366	
Burned Mountain															
17	Poles	82	60.7	5	3.7	18	13.3	0	.0	30	22.2	105	77.8	135	57.7
	Sawtimber	84	84.9	10	10.1	4	4.0	0	.0	1	1.0	98	99.0	99	42.3
	Total	166	70.9	15	6.4	22	9.4	0	.0	31	13.3	203	86.7	234	

[1] Includes all live pole- (5.0 to 8.9 inches d.b.h.) and sawtimber-sized (≥9 inches d.b.h.) trees present on the blocks in July 1981.
[2] Change in tree numbers since time of block establishment (blocks 1-12, 1978; blocks 13-14, 1979) is indicated by a small numeral immediately following the current number of trees. A positive number indicates gain due to growth; a negative number indicates loss due to windthrow, root rot, etc.
[3] All percentages are based on the numbers of trees shown in the "Total, all species" column. For example, on block 5: 20.6 percent of the stand is pole-sized and 79.4 percent is sawtimber-sized; 13.3 percent of the poles are Douglas-fir, 32.8 percent of the sawtimber-sized trees are Douglas-fir, and 28.8 percent of all trees are Douglas-fir.

TABLE 3.--Species composition and stocking levels of seedlings and saplings on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, 1978-81[1] [2] [3]

Location & block	Size class	Douglas-fir (DF)		True fir (TF)		Spruce (SP)		Pine		Aspen		Total host (DF, TF, SP)		Total/acre, all species	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Capulin Canyon															
5	Seed.	100	12.2	478	58.1	0	0	244-11	29.7	0	0	578	70.3	822	87.1
	Sapl.	33	27.1	56	45.9	0	0	33-11	27.0	0	0	89	73.0	122	12.9
	Total	133	14.1	534	56.6	0	0	277	29.3	0	0	667	70.7	944	
6	Seed.	100-11	18.4	444-22	81.6	0	0	0	0	0	0	544	100.0	544	50.0
	Sapl.	111	20.4	433	79.6	0	0	0	0	0	0	544	100.0	544	50.0
	Total	211	19.4	877	80.6	0	0	0	0	0	0	1,088	100.0	1,088	
Garcia Park															
2	Seed.	189+11-11	13.3	633	44.5	0	0	0	0	600+144	42.2	822	57.8	1,422	88.3
	Sapl.	111	58.7	78	41.3	0	0	0	0	0	0	189	100.0	189	11.7
	Total	300	18.6	711	44.1	0	0	0	0	600	37.3	1,011	62.7	1,611	
7	Seed.	78-11	70.3	33	29.7	0	0	0	0	0	0	111	100.0	111	18.9
	Sapl.	389-11	81.6	55	11.5	0	0	33	6.9	0	0	444	93.1	477	81.1
	Total	467	79.4	88	15.0	0	0	33	5.6	0	0	555	94.4	588	
10	Seed.	89	12.4	244	33.8	11	1.5	33	4.6	344	47.7	344	47.7	721	58.0
	Sapl.	200	38.2	156-11	29.8	0	0	89	17.0	78	15.0	356	68.0	523	42.0
	Total	289	23.2	400	32.2	11	0.9	122	9.8	422	33.9	700	56.3	1,244	
La Jara Canyon															
3	Seed.	89	5.3	89-11	5.3	244	14.6	11-22	0.6	1,244-122	74.2	422	25.2	1,677	79.1
	Sapl.	55	12.4	167	37.6	89-11	20.0	0	0	133	30.0	311	70.0	444	20.9
	Total	144	6.8	256	12.1	333	15.7	11	0.5	1,377	64.9	733	34.6	2,121	
4	Seed.	300-11	29.0	56	5.4	133	12.9	11-11	1.1	533-22	51.6	489	47.3	1,033	75.6
	Sapl.	133	40.0	0	0	67	20.1	11	3.3	122	36.6	200	60.1	333	24.4
	Total	433	31.7	56	4.1	200	14.6	22	1.6	655	48.0	689	50.4	1,366	
Palo Flechado Pass															
1	Seed.	478-167	27.1	989-133	56.0	89-22	5.0	11	0.6	200+67	11.3	1,556	88.1	1,767	57.2
	Sapl.	555	42.0	667-56	50.4	0	0	0	0	100	7.6	1,222	92.4	1,322	42.8
	Total	1,033	33.4	1,656	53.6	89	2.9	11	0.4	300	9.7	2,778	89.9	3,089	
8	Seed.	211-11	9.7	1,922-233	87.8	11	0.5	22	1.0	22+33	1.0	2,144	98.0	2,188	83.1
	Sapl.	133-11	30.0	289	65.0	0	0	0	0	22+11	5.0	422	95.0	444	16.9
	Total	344	13.1	2,211	84.0	11	0.4	22	0.8	44	1.7	2,566	97.5	2,632	
Cabresto Canyon															
9	Seed.	811+11-11	80.2	178	17.6	0	0	22	2.2	0	0	989	97.8	1,011	74.6
	Sapl.	322	93.6	22	6.4	0	0	0	0	0	0	344	100.0	344	25.4
	Total	1,133	83.6	200	14.8	0	0	22	1.6	0	0	1,333	98.4	1,355	
11	Seed.	122-11	9.5	811-89+11	63.0	33	2.5	11	0.9	311	24.1	966	75.0	1,288	67.4
	Sapl.	244	39.2	289-11	46.5	22	3.5	0	0	67	10.8	555	89.2	622	32.6
	Total	366	19.1	1,100	57.6	55	2.9	11	0.6	378	19.8	1,521	79.6	1,910	
12	Seed.	489-33	23.8	644	31.3	422-11	20.5	22	1.1	478	23.3	1,555	75.6	2,055	70.1
	Sapl.	300-44	34.2	378	43.1	111	12.6	0	0	89	10.1	789	89.9	878	29.9
	Total	789	26.9	1,022	34.8	533	18.2	22	0.8	567	19.3	2,344	79.9	2,933	
Osha Mountain															
13	Seed.	67-11	13.4	322	64.4	11	2.2	0	0	100+56	20.0	400	80.0	500	56.9
	Sapl.	89	23.6	233	61.6	0	0	0	0	56-22	14.8	322	85.2	378	43.1
	Total	156	17.8	555	63.2	11	1.2	0	0	156	17.8	722	82.2	878	
14	Seed.	211	17.9	367-22	31.2	11	0.9	22	1.9	567-200	48.1	589	50.0	1,178	72.1
	Sapl.	78-11	17.1	244	53.6	100	22.0	0	0	33	7.3	422	92.7	455	27.9
	Total	289	17.7	611	37.4	111	6.8	22	1.4	600	36.7	1,011	61.9	1,633	
15	Seed.	111+11-11	33.4	89-11	26.7	89	26.7	0	0	44-11	13.2	289	86.8	333	57.7
	Sapl.	22	9.0	144	59	78	32.0	0	0	0-111	0	244	100.0	244	42.3
	Total	133	23.1	233	40.4	167	28.9	0	0	44	7.6	533	92.4	577	
16	Seed.	11	1.0	1,011-22	87.5	56-33	4.8	0	0	78-144	6.7	1,078	93.3	1,156	74.8
	Sapl.	22	5.6	189-11	48.6	156	40.1	0	0	22-22	5.7	367	94.3	389	25.2
	Total	33	2.1	1,200	77.7	212	13.7	0	0	100	6.5	1,445	93.5	1,545	
Burned Mountain															
17	Seed.	44	3.8	333	28.6	11	0.9	0	0	778-33	66.7	388	33.3	1,166	75.5
	Sapl.	100	26.5	178	47.1	11	2.9	0	0	89	23.5	289	76.5	378	24.5
	Total	144	9.3	511	38.1	22	1.4	0	0	867	56.2	677	43.8	1,544	

[1] Includes all live seedlings (<0.5 inches d.b.h. and ≥12 inches height) and saplings (0.5 inches ≥ d.b.h.) present on blocks in August 1981. All data shown as trees per acre and based on sampling of nine, 1/100-acre plots per block.

[2] Change in tree numbers since time of block establishment (blocks 1-12, 1978; blocks 13-17, 1979) is indicated by small numerals immediately following the current number of trees. A positive number indicates gain due to growth; a negative number indicates loss due to root rot, animals, etc.

[3] All percentages are based on numbers of trees shown in the "Total/acre, all species" column. For example, on block 5: 87.1 percent of all regeneration-sized trees are seedlings and 12.9 percent are saplings; 12.2 of all seedlings are DF, 27.1 percent of all saplings are DF, and 14.1 percent of all regeneration is DF.

TABLE 4.--Species composition and stocking levels of Douglas-fir (DF), true fir (TF), and spruce (SP) seedlings less than 12 inches in height, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-1981

Location & block	Year	Trees per acre[1] DF	TF	SP	Total
Capulin Canyon 5	1978	89	256	0	345
	1979	133	267	0	400
	1980	122	256	0	378
	1981	122	256	0	378
6	1978	22	89	0	111
	1979	33	89	0	122
	1980	22	89	0	111
	1981	22	67	0	89
Garcia Park 2	1978	22	22	0	44
	1979	89	33	0	122
	1980	33	33	0	66
	1981	33	33	0	66
7	1978	0	33	0	33
	1979	0	33	0	33
	1980	0	44	0	44
	1981	0	22	0	22
10	1978	33	0	0	33
	1979	78	0	0	78
	1980	89	0	0	89
	1981	89	0	0	89
La Jara Canyon 3	1978	44	78	78	200
	1979	89	78	78	245
	1980	78	78	56	212
	1981	22	56	44	122
4	1978	33	33	0	66
	1979	89	33	0	122
	1980	89	33	0	122
	1981	22	0	0	22
Palo Flechado Pass 1	1978	78	44	22	144
	1979	78	44	22	144
	1980	78	44	11	133
	1981	67	55	11	133
8	1978	89	489	11	589
	1979	133	489	0	622
	1980	111	433	0	544
	1981	100	411	0	511
Cabresto Canyon 9	1978	78	22	0	100
	1979	122	22	0	144
	1980	111	22	0	133
	1981	100	11	0	111
11	1978	67	989	289	1,345
	1979	78	1,311	611	2,000
	1980	78	1,200	611	1,889
	1981	122	1,222	811	2,155
12	1978	156	11	22	189
	1979	178	44	22	244
	1980	167	44	22	233
	1981	167	33	33	233
Osha Mountain[2] 13	1978	--	--	--	--
	1979	11	122	0	133
	1980	11	122	0	133
	1981	11	122	0	133
14	1978	--	--	--	--
	1979	133	100	0	233
	1980	133	89	0	222
	1981	133	78	0	211
15	1978	--	--	--	--
	1979	56	111	11	178
	1980	56	122	11	189
	1981	56	133	11	200
16	1978	--	--	--	--
	1979	33	933	111	1,077
	1980	11	911	111	1,033
	1981	11	867	100	978
Burned Mountain[2] 17	1978	--	--	--	--
	1979	22	22	0	44
	1980	11	22	0	33
	1981	11	33	0	44

[1] Based on sample of nine 1/100-acre plots per block.
[2] Blocks 13-17 established 1979.

TABLE 5.--Percent Douglas-fir defoliation on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81

Location	Block	Percent defoliation[1]							
		1978[2]		1979		1980		1981	
		6-class	Visual	6-class	Visual	6-class	Visual	6-class	Visual
Capulin Canyon	5	65.6	54.2	93.4	93.5	79.9	74.7	89.0	88.0
	6	22.0	28.8	60.2	56.1	80.9	84.2	98.9	95.0
Garcia Park	2	47.0	33.7	80.2	72.6	80.8	68.5	96.4	94.4
	7	54.6	35.9	89.6	89.9	79.0	61.7	84.9	88.4
	10	70.2	43.4	90.6	93.0	82.6	80.4	92.8	95.0
La Jara Canyon	3	64.8	50.7	86.0	89.0	79.5	93.1	91.9	92.9
	4	69.1	63.4	86.9	84.6	77.6	87.8	79.9	76.5
Palo Flechado Pass	1	47.5	40.3	88.1	94.7	85.7	78.1	84.2	73.7
	8	66.5	48.9	93.1	91.4	84.0	80.2	95.1	95.0
Cabresto Canyon	9	11.7	6.0	29.1	5.0	66.0	58.6	82.6	77.8
	11	60.7	51.7	95.2	94.3	99.5	95.0	62.9	75.7
	12	50.7	35.3	94.7	95.0	99.6	95.0	68.8	63.8
Average (1-12)		52.5	41.0	82.3	79.9	82.9	79.8	85.6	84.7
Osha Mountain[3]	13	---	---	12.7	5.0	45.9	15.1	99.9	93.6
	14	---	---	9.7	5.0	36.1	6.1	97.9	92.7
	15	---	---	7.5	5.0	20.4	5.0	93.9	95.0
	16	---	---	1.4	5.0	1.8	5.0	75.5	73.4
Average (13-16)		---	---	7.8	5.0	26.1	7.8	91.8	88.7
Burned Mountain[4]	17	---	---	0.0	5.0	25.7	5.0	27.5	5.0

[1] Each block percentage is the average defoliation of 10 single-tree samples.
[2] Blocks 13-17 were established in 1979.
[3] Budworm first observed in 1979.
[4] Budworm first observed in 1980.

TABLE 6.--Top-kill of pole-sized (5.0-8.9 inches d.b.h.) host trees on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81[1]

Location & block	Species	No. of trees[2]	% Old top-kill[3]	% New top-kill						
				Apparent				Confirmed[4]		
				1978	1979	1980	1981	1978	1979	1980
Capulin Canyon										
5	DF	2	.0	50.0	50.0	50.0	50.0	.0	.0	.0
	TF	3	.0	.0	.0	33.3	66.6	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	5	.0	20.0	20.0	40.0	60.0	.0	.0	.0
6	DF	13	.0	53.8	.0	38.5	30.8	.0	.0	23.1
	TF	14	.0	.0	7.1	7.1	7.1	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	27	.0	25.9	3.7	22.2	18.5	.0	.0	11.1
Garcia Park										
2	DF	129	12.4	.0	0.8	14.7	2.3	.0	0.8	1.6
	TF	8	50.0	.0	.0	12.5	.0	.0	.0	.0
	SP	1	100.0	--	--	--	--	--	--	--
	Total	138	15.2	.0	0.7	14.5	2.2	.0	0.7	1.5
7	DF	138	1.4	.0	2.0	20.3	7.2	.0	0.7	4.3
	TF	4	.0	.0	25.0	75.0	50.0	.0	25.0	50.0
	SP	0	--	--	--	--	--	--	--	--
	Total	142	1.4	.0	2.8	21.8	8.5	.0	1.4	5.6
10	DF	59	10.2	5.1	11.9	35.6	18.6	.0	.0	8.5
	TF	14	14.3	.0	21.4	35.7	28.6	.0	7.1	14.3
	SP	1	.0	.0	.0	100.0	.0	.0	.0	.0
	Total	74	10.8	4.1	13.5	36.5	20.3	.0	1.4	9.5
La Jara Canyon										
3	DF	17	17.6	.0	.0	29.4	17.6	.0	.0	.0
	TF	12	33.3	.0	8.3	16.7	25.0	.0	.0	.0
	SP	18	.0	.0	.0	55.6	22.2	.0	.0	5.6
	Total	47	14.9	.0	2.1	36.2	21.3	.0	.0	2.1
4	DF	26	.0	7.7	38.5	61.5	34.6	7.7	23.1	23.1
	TF	5	.0	.0	60.0	80.0	80.0	.0	20.0	40.0
	SP	26	.0	.0	50.0	80.8	61.5	.0	23.1	34.6
	Total	57	.0	3.5	45.6	71.9	50.9	3.5	22.8	29.8
Palo Flechado Pass										
1	DF	90	3.3	.0	10.7	25.6	15.6	.0	5.6	8.9
	TF	48	8.3	4.2	10.4	33.3	14.6	.0	6.3	12.5
	SP	6	.0	.0	.0	.0	.0	.0	.0	.0
	Total	144	4.9	1.4	13.9	27.1	14.6	.0	5.6	9.7
8	DF	60	5.0	1.7	8.3	26.7	10.0	.0	6.7	6.7
	TF	5	40.0	.0	.0	20.0	20.0	.0	.0	.0
	SP	1	.0	100.0	.0	100.0	.0	.0	.0	.0
	Total	66	7.6	3.0	7.6	27.3	10.6	.0	6.1	6.1
Cabresto Canyon										
9	DF	61	1.6	1.6	.0	.0	.0	.0	.0	.0
	TF	2	.0	.0	.0	.0	.0	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	63	1.6	1.6	.0	.0	.0	.0	.0	.0
11	DF	57	.0	.0	7.2	57.9	35.1	.0	3.5	19.3
	TF	12	8.3	16.7	25.0	66.7	50.0	.0	8.3	16.7
	SP	15	.0	.0	.0	46.7	40.0	.0	.0	6.7
	Total	84	1.2	2.4	8.3	57.1	38.1	.0	3.6	16.7
12	DF	81	.0	.0	2.5	9.9	9.9	.0	.0	1.2
	TF	8	12.5	.0	.0	.0	.0	.0	.0	.0
	SP	39	2.6	2.6	2.6	2.6	2.6	.0	.0	.0
	Total	128	1.6	0.8	2.3	7.0	7.0	.0	.0	0.8
Combined										
1-12	DF	733	4.6	2.0	6.5	23.9	12.1	0.3	2.6	6.3
	TF	135	13.3	3.0	12.6	31.1	22.2	.0	5.2	10.4
	SP	107	1.9	1.9	13.1	38.3	25.2	.0	5.6	10.3
	Total	975	5.5	2.2	8.1	26.5	15.0	0.2	3.3	7.3
Osha Mountain										
13	DF	107	5.6	--	.0	.0	.0	--	.0	.0
	TF	7	14.3	--	.0	.0	.0	--	.0	.0
	SP	3	.0	--	.0	.0	.0	--	.0	.0
	Total	117	6.0	--	.0	.0	.0	--	.0	.0
14	DF	49	12.2	--	.0	2.0	2.0	--	.0	.0
	TF	33	21.2	--	3.0	6.1	9.1	--	.0	.0
	SP	4	.0	--	.0	.0	.0	--	.0	.0
	Total	86	15.1	--	1.2	3.5	4.7	--	.0	.0
15	DF	32	3.1	--	.0	.0	.0	--	.0	.0
	TF	16	12.5	--	.0	.0	18.8	--	.0	.0
	SP	46	6.5	--	.0	.0	6.5	--	.0	.0
	Total	94	6.4	--	.0	.0	6.4	--	.0	.0
16	DF	16	.0	--	.0	.0	.0	--	.0	.0
	TF	50	6.0	--	2.0	.0	.0	--	.0	.0
	SP	183	4.4	--	.0	.0	.0	--	.0	.0
	Total	249	4.4	--	0.4	.0	.0	--	.0	.0
Combined										
13-16	DF	204	6.4	--	.0	0.5	0.5	--	.0	.0
	TF	106	12.3	--	1.9	1.9	5.7	--	.0	.0
	SP	236	4.7	--	.0	.0	1.3	--	.0	.0
	Total	546	6.8	--	0.4	0.5	1.8	--	.0	.0
Burned Mountain										
17	DF	82	9.8	--	.0	.0	.0	--	.0	.0
	TF	5	40.0	--	.0	.0	.0	--	.0	.0
	SP	18	5.6	--	.0	5.6	.0	--	.0	.0
	Total	105	10.5	--	.0	1.0	.0	--	.0	.0

[1] Blocks 1-12 established 1978; blocks 13-17, 1979. Blocks 13-16 became infested 1979; block 17, 1980.
[2] Includes all trees tagged since initiation of project, including trees gained through ingrowth and lost through mortality.
[3] Includes top-kill and broken tops prior to and not attributable to current budworm infestation.
[4] Figures are accumulative.

TABLE 7.--Top-killed sawtimber-sized (≥9.0 inches d.b.h.) host trees on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81[1]

Location & block	Species	No. of trees[2]	% Old top-kill[3]	New top-kill						
				Apparent				Confirmed[4]		
				1978	1979	1980	1981	1978	1979	1980
Capulin Canyon										
5	DF	19	.0	31.6	5.3	47.4	31.6	.0	5.3	21.1
	TF	5	.0	.0	20.0	20.0	40.0	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	24	.0	25.0	8.3	41.7	33.3	.0	4.2	16.7
6	DF	16	.0	43.8	.0	31.3	37.5	.0	.0	25.0
	TF	8	.0	.0	.0	.0	.0	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	24	.0	29.2	.0	20.8	25.0	.0	.0	16.7
Garcia Park										
2	DF	73	1.4	.0	6.9	16.4	6.9	.0	1.4	2.7
	TF	7	28.6	.0	.0	14.3	.0	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	80	3.8	.0	6.3	16.3	6.3	.0	1.3	2.5
7	DF	71	1.4	.0	.0	5.6	2.8	.0	.0	1.4
	TF	2	.0	.0	50.0	.0	50.0	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	73	1.4	.0	1.4	5.5	4.1	.0	.0	1.4
10	DF	24	4.2	.0	.0	20.8	8.3	.0	.0	8.3
	TF	6	16.7	.0	33.3	66.7	33.3	.0	16.7	16.7
	SP	1	100.0	--	--	--	--	--	--	--
	Total	31	9.7	.0	6.5	29.0	12.9	.0	3.2	9.7
La Jara Canyon										
3	DF	30	6.7	.0	.0	20.0	13.3	.0	.0	.0
	TF	2	.0	.0	50.0	50.0	50.0	.0	50.0	50.0
	SP	28	7.1	.0	3.6	21.4	7.1	.0	3.6	3.6
	Total	60	6.7	.0	3.3	21.7	11.7	.0	3.3	3.3
4	DF	50	2.0	.0	12.0	14.0	10.0	.0	2.0	4.0
	TF	0	--	--	--	--	--	--	--	--
	SP	10	10.0	.0	40.0	70.0	20.0	.0	20.0	20.0
	Total	60	3.3	.0	16.7	23.3	11.7	.0	5.0	6.7
Palo Flechado Pass										
1	DF	31	.0	.0	3.2	.0	.0	.0	.0	.0
	TF	16	25.0	12.5	12.5	25.0	12.5	12.5	12.5	12.5
	SP	2	.0	.0	.0	.0	.0	.0	.0	.0
	Total	49	8.2	4.1	6.1	8.2	4.1	4.1	4.1	4.1
8	DF	59	3.4	1.7	1.7	17.0	3.4	.0	.0	1.7
	TF	13	15.4	7.7	.0	46.2	15.4	.0	.0	7.7
	SP	0	--	--	--	--	--	--	--	--
	Total	72	5.6	2.8	1.4	22.2	5.6	.0	.0	2.8
Cabresto Canyon										
9	DF	33	.0	.0	.0	.0	3.0	.0	.0	.0
	TF	2	.0	.0	.0	.0	.0	.0	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	35	.0	.0	.0	.0	2.9	.0	.0	.0
11	DF	28	.0	.0	.0	53.6	17.9	.0	.0	3.6
	TF	8	.0	.0	12.5	75.0	50.0	.0	.0	12.5
	SP	7	.0	.0	.0	14.3	14.3	.0	.0	.0
	Total	43	.0	.0	2.3	51.2	23.3	.0	.0	4.7
12	DF	37	2.7	.0	.0	5.4	.0	.0	.0	.0
	TF	3	.0	.0	.0	.0	.0	.0	.0	.0
	SP	9	.0	.0	.0	.0	.0	.0	.0	.0
	Total	49	2.0	.0	.0	4.1	.0	.0	.0	.0
Combined										
1-12	DF	471	1.9	3.0	3.0	15.9	8.1	.0	0.6	3.6
	TF	72	12.5	4.2	11.1	31.9	19.4	2.8	5.6	8.3
	SP	57	7.0	.0	8.8	24.6	8.9	.0	5.3	5.3
	Total	600	3.7	2.8	4.5	18.7	9.5	0.3	1.7	4.3
Osha Mountain										
13	DF	45	2.2	--	.0	.0	2.2	--	.0	.0
	TF	1	.0	--	.0	.0	.0	--	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	46	2.2	--	.0	.0	2.2	--	.0	.0
14	DF	36	5.6	--	2.8	2.8	.0	--	.0	.0
	TF	25	16.0	--	.0	.0	.0	--	.0	.0
	SP	0	--	--	--	--	--	--	--	--
	Total	61	9.8	--	1.6	1.6	.0	--	.0	.0
15	DF	79	5.1	--	.0	1.3	2.5	--	.0	1.3
	TF	3	33.3	--	.0	.0	.0	--	.0	.0
	SP	9	.0	--	.0	.0	.0	--	.0	.0
	Total	91	5.5	--	.0	1.1	2.2	--	.0	1.1
16	DF	24	4.2	--	.0	.0	.0	--	.0	.0
	TF	4	.0	--	.0	.0	.0	--	.0	.0
	SP	36	.0	--	.0	.0	.0	--	.0	.0
	Total	64	1.6	--	.0	.0	.0	--	.0	.0
Combined										
13-16	DF	184	4.4	--	0.5	1.1	1.6	--	.0	0.5
	TF	33	15.2	--	.0	.0	.0	--	.0	.0
	SP	45	.0	--	.0	.0	.0	--	.0	.0
	Total	262	5.0	--	0.4	0.8	1.1	--	.0	0.4
Burned Mountain										
17	DF	84	3.6	--	.0	.0	.0	--	.0	.0
	TF	10	.0	--	.0	.0	.0	--	.0	.0
	SP	4	.0	--	.0	.0	.0	--	.0	.0
	Total	98	3.1	--	.0	.0	.0	--	.0	.0

[1] Blocks 1-12 established 1978; blocks 13-17, 1979. Blocks 13-16 became infected 1979; block 17, 1980.
[2] Includes all trees tagged since initiation of project, including trees gained through growth and lost through mortality.
[3] Includes top-kill and broken tops prior to and not attributable to current budworm infestation.
[4] Figures are cumulative.

TABLE 8.--Mortality of pole- and sawtimber-sized host trees[1] on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81[2]

Location	Block	Total poles[4]	% Pole Mortality[3]				Total sawtimber[4]	% Sawtimber Mortality[3]			
			1978	1979	1980	1981		1978	1979	1980	1981
Capulin Canyon	5	5	.0	.0	.0	.0	24	.0	.0	.0	.0
	6	27	.0	.0	.0	.0	24	.0	.0	.0	.0
Garcia Park	2	138	.0	.0	0.7	2.2	80	.0	.0	.0	1.3
	7	142	.0	0.7	0.7	0.7	73	.0	.0	.0	.0
	10	74	.0	.0	.0	.0	31	.0	.0	.0	.0
La Jara Canyon	3	47	.0	4.3	4.3	4.3	60	.0	5.0	5.0	6.7
	4	57	.0	.0	.0	.0	60	.0	.0	.0	.0
Palo Flechado Pass	1	144	.0	.0	.0	.7	49	.0	2.0	2.0	2.0
	8	66	.0	.0	.0	.0	72	.0	.0	.0	.0
Cabresto Canyon	9	63	.0	.0	.0	.0	35	.0	.0	.0	.0
	11	84	.0	.0	1.2	1.2	43	.0	.0	.0	.0
	12	128	.0	.0	.0	.0	49	.0	.0	.0	.0
Combined	1-12	975	.0	0.3	0.5	0.8	600	.0	0.7	0.7	1.0
Osha Mountain	13	117	--	.0	.0	0.9	46	--	.0	.0	.0
	14	86	--	.0	.0	.0	61	--	.0	.0	.0
	15	94	--	.0	.0	.0	91	--	.0	.0	.0
	16	249	--	.0	0.4	0.4	64	--	.0	.0	.0
Combined	13-16	546	--	.0	0.2	0.4	262	--	.0	.0	.0
Burned Mountain	17	105	--	.0	.0	.0	98	--	.0	.0	.0

[1] Douglas-fir, true firs, and spruce; pole-sized = 5.0-8.9 inches d.b.h.; sawtimber-sized = ≥9.0 inches d.b.h.
[2] Blocks 1-12 established 1978; blocks 13-17, 1979. Blocks 13-16 became infested 1979; block 17, 1980.
[3] Figures are cumulative.
[4] Includes all trees tagged since initiation of project; includes trees gained through growth and lost through mortality.

TABLE 9.--Disease conditions on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-1981

Location	Block	Disease conditions[1]
Capulin Canyon	5	Low incidence broom rust, TF.
	6	Low incidence broom rust, TF. Severe dwarf mistletoe, PP. *Armillariella mellea* (=*Armillaria mellea*) and *Fomitopsis annosa* (=*Fomes annosus*), PP.
Garcia Park	2	*Phaeolus schweinitzii* (=*Polyporus schweinitzii*), DF. *A. mellea* present.
	7	Severe dwarf mistletoe, DF, on half of block. *A. mellea* present.
	10	*A. mellea* and *F. annosa* present.
La Jara Canyon	3	*Inonotus tomentosus* (=*Polyporus tomentosus*), (=*Polyporus circinatus*), SP. *A. mellea*, SP, DF.
	4	*P. schweinitzii*, SP. *A. mellea* present.
Palo Flechado Pass	1	Overstocked. *A. mellea* present.
	8	*A. mellea* and *F. annosa*; at least 1/4 of block infested.
Cabresto Canyon	9	Not examined.
	11	No discernible disease.
	12	No discernible disease.
Osha Mountain	13	*A. mellea* present.
	14	Severe dwarf mistletoe, DF. *A. mellea* and *F. annosa* present.
	15	*A. mellea* present in two small discrete centers, plus several indiscrete ones. Low incidence broom rust, SP.
	16	Overstocked. *A. mellea* present, found on dead saplings. Low incidence broom rust, SP.
Burned Mountain	17	Not examined.

[1] DF = Douglas-fir; TF = true fir; SP = spruce.
A. mellea and *F. annosa* affect DF, TF, and SP.
P. schweinitzii affects DF, TF, and SP.
I. tomentosus affects SP.

TABLE 10.--Factors contributing to mortality of pole- and sawtimber-sized trees on 1-acre blocks, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81

Location	Block	Year dead[1]	Tree species and size[2]	Factors Contributing to Mortality[3]								
				SBW	BkB	WdB	RR	WTh	DM	Cut	Unk	Sup
Capulin Canyon	6	1980	PP:p								X	
Garcia Park	2	1980	DF:p	X							X	
		1981	DF:p							X		
		1981	DF:p	X			X					
		1981	DF:s	X							X	
	7	1979	DF:p								X	
La Jara Canyon	3	1979	DF:p					X				
		1979	DF:s					X				
		1979	TF:p								X	
		1979	SP:s				X	X				
		1979	SP:s					X				
		1981	SP:s	X		X	X					
Palo Flechado Pass	1	1979	TF:s				X					X
		1981	TF:p	X							X	
	8	1979	PP:p								X	
Cabresto Canyon	11	1980	DF:p							X		
Osha Mountain	13	1981	TF:p	X	X		X					
	16	1980	SP:p								X	X

[1] Year death confirmed.

[2] DF = Douglas-fir; TF = true fir; SP = spruce; PP = ponderosa pine; p = pole (5.0-8.9 inches d.b.h.); s = sawtimber (≥9 inches d.b.h.).

[3] SBW = spruce budworm; BkB = bark beetles; WdB = woodborers; RR = root rot; WTh = windthrow; DM = dwarf mistletoe; Cut = cut down; Unk = unknown; Sup = suppressed tree or overstocked stand.

TABLE 11.--Top-kill and mortality of host-tree seedlings, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-1981[1]

Location & block	Species	No. trees per acre[2]	Percent trees affected[3]										
			Other damage[4]	Apparent top-kill				Confirmed top-kill			Mortality			
				1978	1979	1980	1981	1978	1979	1980	1978	1979	1980	1981
Capulin Canyon														
5	DF	100	0	0	11.1	11.1	55.6	0	0	0	0	0	0	0
	TF	478	0	0	0	20.9	34.9	0	0	20.9	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	578	0	0	1.9	19.2	38.5	0	0	17.3	0	0	0	0
6	DF	111	0	0	10.0	30.0	50.0	0	10.0	20.0	0	0	0	10.0
	TF	467	0	0	11.9	19.0	71.4	0	11.9	16.7	0	2.4	4.8	4.8
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	578	0	0	11.5	21.2	67.3	0	11.5	17.3	0	1.9	3.8	9.6
Garcia Park														
2	DF	200	0	0	0	27.8	16.7	0	0	5.6	0	0	5.6	5.6
	TF	633	0	0	1.8	43.9	21.1	0	1.8	8.8	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	833	0	0	1.3	40.0	26.0	0	1.3	8.0	0	0	1.3	1.3
7	DF	89	0	0	0	50.0	50.0	0	0	25.0	0	0	0	12.5
	TF	33	0	0	0	3.3	3.3	0	0	3.3	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	122	0	0	0	45.0	45.0	0	0	27.3	0	0	0	9.1
10	DF	89	0	0	0	37.5	62.5	0	0	25.0	0	0	0	0
	TF	244	0	0	4.6	27.3	45.5	0	4.5	22.7	0	0	0	0
	SP	11	0	0	0	100.0	0	0	0	0	0	0	0	0
	Total	344	0	0	3.2	32.3	48.4	0	3.2	22.6	0	0	0	0
La Jara Canyon														
3	DF	89	0	0	0	0	12.5	0	0	0	0	0	0	0
	TF	100	11.1	0	0	22.2	33.3	0	0	11.1	0	0	0	0
	SP	244	0	0	0	18.2	27.3	0	0	13.6	0	0	0	0
	Total	433	2.6	0	0	15.4	25.6	0	0	10.3	0	0	0	0
4	DF	311	0	0	0	17.9	25.0	0	0	10.7	0	0	0	3.6
	TF	56	0	0	0	20.0	20.0	0	0	20.0	0	0	0	0
	SP	133	0	0	0	25.0	75.0	0	0	25.0	0	0	0	0
	Total	500	0	0	0	20.0	37.8	0	0	15.6	0	0	0	2.2
Palo Flechado Pass														
1	DF	644	0	0	13.8	44.8	56.9	0	13.8	41.4	0	1.7	13.8	25.9
	TF	1,122	2.0	0	6.9	23.8	40.6	0	5.9	19.8	0	3.0	5.9	11.9
	SP	111	0	0	10.0	10.0	20.0	0	10.0	10.0	0	0	20.0	20.0
	Total	1,877	1.2	0	9.5	30.2	45.0	0	8.9	26.6	0	2.4	9.5	17.2
8	DF	222	5.0	0	0	15.0	20.0	0	0	5.0	0	5.0	5.0	5.0
	TF	2,155	0.5	0	1.5	6.7	12.4	0	1.5	4.1	0.5	3.1	8.2	10.8
	SP	11	0	0	0	0	100.0	0	0	0	0	0	0	0
	Total	2,388	0.9	0	1.4	7.4	13.5	0	1.4	4.2	0.5	3.3	7.9	10.2
Cabresto Canyon														
9	DF	822	0	0	0	10.8	17.6	0	0	2.7	0	1.4	1.4	1.4
	TF	178	0	0	0	25.0	31.3	0	0	0	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1,000	0	0	0	13.3	20.0	0	0	2.2	0	1.1	1.1	1.1
11	DF	133	0	0	0	16.7	58.3	0	0	8.3	0	0	0	8.3
	TF	900	0	0	4.9	25.9	24.7	0	2.5	14.8	0	2.5	6.2	9.9
	SP	33	0	0	0	3.3	3.3	0	0	3.3	0	0	0	0
	Total	1,066	0	0	4.2	25.0	29.2	0	2.1	14.6	0	2.1	5.2	9.4
12	DF	522	4.3	0	2.1	4.3	29.8	0	0	4.3	0	0	2.1	6.4
	TF	644	1.7	0	0	12.1	36.2	0	0	8.9	0	0	0	0
	SP	433	2.6	0	0	10.3	30.8	0	0	10.3	0	0	0	2.6
	Total	1,599	2.8	0	0.7	9.0	32.6	0	0	6.9	0	0	0.7	2.8
Combined														
1-12	DF	3,332	1.0	0	3.7	20.7	33.7	0	3.0	13.3	0	1.0	4.0	8.3
	TF	7,010	0.8	0	3.3	19.2	29.0	0	2.9	11.6	0.2	1.9	4.6	6.8
	SP	976	1.1	0	1.1	15.9	35.2	0	1.1	13.6	0	0	2.3	3.4
	Total	11,318	0.9	0	3.2	19.3	30.9	0	2.7	12.3	0.1	1.5	4.2	7.0
Usha Mountain														
13	DF	78	28.6	--	0	0	14.3	--	0	0	--	14.3	14.3	14.3
	TF	322	3.4	--	3.4	3.4	27.6	--	3.4	3.4	--	0	0	0
	SP	11	0	--	0	0	0	--	0	0	--	0	0	0
	Total	411	8.1	--	2.7	2.7	24.3	--	2.7	2.7	--	2.7	2.7	2.7
14	DF	211	0	--	0	0	15.8	--	0	0	--	0	0	0
	TF	389	2.9	--	0	17.1	34.3	--	0	14.3	--	0	5.7	5.7
	SP	11	0	--	0	0	0	--	0	0	--	0	0	0
	Total	611	1.8	--	0	10.9	27.3	--	0	9.1	--	0	3.6	3.6
15	DF	122	0	--	0	0	9.1	--	0	0	--	0	0	9.1
	TF	100	0	--	0	11.1	11.1	--	0	11.1	--	0	0	11.1
	SP	89	0	--	0	0	12.5	--	0	0	--	0	0	0
	Total	311	0	--	0	3.6	10.7	--	0	3.6	--	0	0	7.1
16	DF	11	0	--	0	0	0	--	0	0	--	0	0	0
	TF	1,033	1.1	--	0	1.1	2.2	--	0	1.1	--	1.1	1.1	2.2
	SP	89	12.5	--	0	0	0	--	0	0	--	0	25.0	37.5
	Total	1,133	2.0	--	0	1.0	2.0	--	0	1.0	--	1.0	2.9	4.9
Combined														
13-16	DF	422	9.3	--	0	0	13.2	--	0	0	--	2.6	2.6	5.3
	TF	1,844	1.8	--	0.6	5.4	13.8	--	0.6	4.8	--	0.6	1.8	3.0
	SP	200	6.5	--	0	0	6.5	--	0	0	--	0	11.1	16.7
	Total	2,466	2.7	--	0.4	4.0	13.1	--	0.4	3.0	--	0.9	2.7	4.5
Burned Mountain														
17	DF	44	25.0	--	0	0	0	--	0	0	--	0	0	0
	TF	333	10.0	--	0	13.3	0	--	0	0	--	0	0	0
	SP	11	0	--	0	0	0	--	0	0	--	0	0	0
	Total	388	11.4	--	0	11.4	0	--	0	0	--	0	0	0

[1] Blocks 1-12 established 1978; 13-17 in 1979.
[2] Includes trees with height ≥12 inches and d.b.h. <0.5 inches. Based on sample of nine 1/100-acre plots per block. Includes all trees tagged since initiation of project.
[3] Except for apparent top-kill, figures are cumulative.
[4] Includes trees with old top-kill and broken tops and trees identified as killed or badly injured by animals or man.

TABLE 12.--Top-kill and mortality of host-tree saplings, Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-1981[1]

Location & block	Species	No. trees per acre[2]	Other damage[3]	Percent trees affected[3]										
				Apparent top-kill				Confirmed top-kill			Mortality			
				1978	1979	1980	1981	1978	1979	1980	1978	1979	1980	1981
Capulin Canyon														
5	DF	33	0	0	0	66.7	100.0	0	0	66.7	0	0	0	0
	TF	56	0	0	0	40.0	60.0	0	0	40.0	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	89	0	0	0	50.0	75.0	0	0	50.0	0	0	0	0
6	DF	111	0	0	0	20.0	10.0	0	0	0	0	0	0	0
	TF	433	0	0	0	0	2.6	0	0	0	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	544	0	0	0	4.1	4.1	0	0	0	0	0	0	0
Garcia Park														
2	DF	111	10.0	0	20.0	20.0	40.0	0	20.0	20.0	0	0	0	0
	TF	78	14.3	0	0	14.3	14.3	0	0	0	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	189	11.8	0	11.8	17.6	29.4	0	11.8	11.8	0	0	0	0
7	DF	400	0	0	2.8	22.2	22.2	0	2.8	11.1	0	0	0	2.8
	TF	56	0	0	0	60.0	20.0	0	0	20.0	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	456	0	0	2.4	26.8	21.9	0	2.4	12.2	0	0	0	2.4
10	DF	200	0	0	0	22.2	33.3	0	0	11.1	0	0	0	0
	TF	167	0	0	6.7	6.7	13.3	0	0	0	0	0	6.7	6.7
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	367	0	0	3.0	15.1	24.2	0	0	6.1	0	0	3.0	3.0
La Jara Canyon														
3	DF	55	0	0	0	0	0	0	0	0	0	0	0	0
	TF	167	0	0	0	6.7	13.3	0	0	6.7	0	0	0	0
	SP	100	11.1	0	0	11.1	11.1	0	0	11.1	0	0	0	0
	Total	322	3.4	0	0	6.9	10.3	0	0	6.9	0	0	0	0
4	DF	144	0	0	7.7	15.4	15.4	0	7.7	15.4	7.7	7.7	7.7	7.7
	TF	0	0	0	0	0	0	0	0	0	0	0	0	0
	SP	67	0	0	16.7	33.3	83.3	0	16.7	33.3	0	0	0	0
	Total	211	0	0	10.5	21.1	36.8	0	10.5	21.1	5.3	5.3	5.3	5.3
Palo Flechado Pass														
1	DF	556	0	0	26.0	46.0	66.0	0	22.0	44.0	0	0	0	0
	TF	722	0	0	13.8	12.3	16.9	0	9.2	12.3	0	0	0	7.7
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	1,278	0	0	19.1	27.0	38.3	0	14.8	26.1	0	0	0	4.3
8	DF	144	0	0	23.1	23.1	30.8	0	15.4	23.1	0	0	0	7.7
	TF	289	0	0	0	0	0	0	0	0	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	433	0	0	7.7	7.7	10.3	0	5.1	7.7	0	0	0	2.6
Cabresto Canyon														
9	DF	322	0	0	0	0	3.4	0	0	0	0	0	0	0
	TF	22	0	0	0	0	50.0	0	0	0	0	0	0	0
	SP	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total	344	0	0	0	0	6.5	0	0	0	0	0	0	0
11	DF	244	0	0	0	0	31.3	0	0	0	0	0	0	0
	TF	300	3.7	0	0	0	14.8	0	0	0	0	0	0	0
	SP	22	0	0	0	0	100.0	0	0	0	0	0	0	0
	Total	566	2.0	0	0	0	25.5	0	0	0	0	0	0	0
12	DF	344	6.5	0	0	3.2	6.5	0	0	0	0	0	3.2	6.5
	TF	376	0	0	0	0	8.6	0	0	0	0	0	0	0
	SP	111	0	0	0	0	10.0	0	0	0	0	0	0	0
	Total	833	2.7	0	0	1.3	8.0	0	0	0	0	0	1.3	2.7
Combined														
1-12	DF	2,664	1.2	0	8.3	19.6	29.8	0	7.1	15.4	0.4	0.4	0.8	1.1
	TF	2,668	0.8	0	4.2	6.7	12.1	0	2.5	5.0	0	0	0.4	1.6
	SP	300	3.7	0	3.7	11.1	33.3	0	3.7	11.1	0	0	0	0
	Total	5,632	1.2	0	5.1	13.0	21.5	0	4.7	10.3	0.2	0.2	0.6	1.2
Usha Mountain														
13	DF	89	0	--	0	0	0	--	0	0	--	0	0	0
	TF	233	0	--	0	0	9.1	--	0	0	--	0	0	0
	SP	0	0	--	0	0	0	--	0	0	--	0	0	0
	Total	322	0	--	0	0	6.9	--	0	0	--	0	0	0
14	DF	89	12.5	--	0	0	12.5	--	0	0	--	0	0	0
	TF	244	0	--	0	4.5	13.6	--	0	4.5	--	0	0	0
	SP	100	0	--	0	0	22.2	--	0	0	--	0	0	0
	Total	433	2.9	--	0	2.9	15.4	--	0	2.9	--	0	0	0
15	DF	22	0	--	0	0	0	--	0	0	--	0	0	0
	TF	144	0	--	0	0	7.7	--	0	0	--	0	0	0
	SP	78	0	--	0	0	0	--	0	0	--	0	0	0
	Total	244	0	--	0	0	4.3	--	0	0	--	0	0	0
16	DF	22	50.0	--	0	0	0	--	0	0	--	0	0	0
	TF	200	5.0	--	0	5.0	25.0	--	0	5.0	--	0	0	5.0
	SP	156	7.1	--	0	0	28.6	--	0	0	--	0	0	0
	Total	378	8.8	--	0	2.9	26.4	--	0	2.9	--	0	0	2.9
Combined														
13-16	DF	322	10.0	--	0	0	3.4	--	0	0	--	0	0	0
	TF	821	1.4	--	0	2.7	16.2	--	0	2.7	--	0	0	1.4
	SP	334	3.3	--	0	0	33.3	--	0	0	--	0	0	0
	Total	1,377	3.2	--	0	1.6	15.3	--	0	1.6	--	0	0	1.2
Burned Mountain														
17	DF	100	0	--	0	0	0	--	0	0	--	0	0	0
	TF	178	12.5	--	0	0	0	--	0	0	--	0	0	0
	SP	11	0	--	0	0	0	--	0	0	--	0	0	0
	Total	289	7.7	--	0	0	0	--	0	0	--	0	0	0

[1] Blocks 1-12 established 1978; 13-17 in 1979.
[2] Includes trees with d.b.h. of 0.5 to 4.9 inches. Based on sample of nine 1/100-acre plots per block. Includes all trees tagged since initiation of project.
[3] Except for apparent top-kill, figures are cumulative.
[4] Includes trees with old top-kill and broken tops; trees identified as killed or badly injured by animals or man.

TABLE 13.--Larval and egg mass densities,[1] Western Spruce Budworm Damage Assessment Project, Carson National Forest, New Mexico, 1978-81[2]

Location	Block	Larvae/100 buds			Egg masses/m^2 of foliage			
		1979	1980	1981	1978	1979	1980	1981
Capulin Canyon	5	29.2	14.3	19.8	25.1	32.8	92.7	21.2
	6	15.9	19.6	27.6	13.1	36.6	89.6	18.6
Garcia Park	2	20.3	15.7	18.0	11.1	34.0	72.2	20.4
	7	29.2	13.6	14.9	27.3	47.6	39.3	16.6
	10	28.9	15.2	16.5	21.5	40.2	78.5	13.4
La Jara Canyon	3	26.8	14.6	18.7	17.0	39.5	31.8	5.9
	4	21.7	13.0	13.1	34.9	35.1	50.9	25.3
Palo Flechado Pass	1	36.6	19.6	14.2	41.1	25.2	66.8	13.4
	8	33.2	15.2	20.4	24.2	33.0	71.2	16.3
Cabresto Canyon	9	7.7	19.1	24.1	3.6	21.5	24.4	34.1
	11	28.9	22.9	8.7	15.2	67.9	42.5	42.2
	12	25.9	15.0	12.0	13.6	39.6	43.8	56.4
Average	1-12	25.4	16.5	17.3	20.6	37.8	58.6	23.7
Osha Mountain	13	0.8	12.9	18.7	---	25.4	32.0	20.8
	14	0.2	3.1	15.8	---	16.5	14.3	30.6
	15	0.3	1.9	19.4	---	.0	13.7	16.6
	16	0.1	1.5	16.2	---	3.3	5.4	24.4
Average	13-16	0.4	4.8	17.5	---	11.3	16.4	23.1
Burned Mountain	17	.0	0.8	2.4	---	.0	1.8	8.5

[1] On each block: average density for 10 Douglas-fir trees; 2 branches per tree.
[2] Blocks 1-12 established in 1978; 13-17 in 1979.